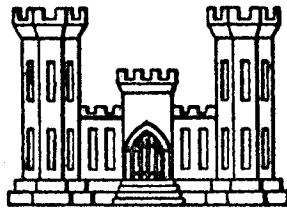


WAR DEPARTMENT  
CORPS OF ENGINEERS, U. S. ARMY  
MISSISSIPPI RIVER COMMISSION

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SUPPLEMENTARY MODEL STUDY OF STILLING BASIN  
FOR SPILLWAY AND SLUICES  
FORT GIBSON DAM, GRAND RIVER OKLAHOMA



TECHNICAL MEMORANDUM NO. 2-228

U. S. WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

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JANUARY 1947

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FORT GIBSON MODEL TEST DATA (1)

COMPARISON OF 50-FOOT APRON AND 70-FOOT APRON

SLUICES ONLY MODEL 1:20 SCALE (3 Sluices)

Pool El	Sluice Outlet El	Apron El	No. Sluices	T.W. El	Apron Length(ft)	Max Bottom Velocity ft/sec	Min Scour El	Plate Ref
554	498	478	1	491.3	50	20	476	7.8
"	"	"	"	"	70	10	478	12.13
"	"	"	3	496.7	50	14	474	9.10
"	"	"	"	"	70	11	474	14.15
"	"	"	3	511.5	50	6	-	11
"	"	"	"	"	70	5	-	16
"	493	481	1	491.3	50	19	479	22.23*
"	"	"	3	496.7	50	5	479	24.25*
"	"	"	3	511.5	50	0	-	26 *

\* With training walls.

COMBINED SLUICE & SPILLWAY MODEL 1:20 SCALE (1 sluice / 2, half bays)

Pool El	Sluice Outlet El	Apron El	Total Q - cfs	T.W. El	Apron Length (ft)	Max Bot- tom Vel- ocity ft/sec	Min Scour El	Plate Ref
552.8	498	481	100,000	511.5	50	4	479	27.29
					70	3	483	28.30

SPILLWAY ONLY MODEL 1:60 SCALE (1' wide flume)

Apron El	Total Q - cfs	T.W. El	Apron Length(ft)	Max Bot- tom Vel- ocity ft/sec	Min Scour El	Plate Ref
485	1,020,000	545.5	50	16	N	34
			70	16	o	35
"	300,000	525.8	50	13	s	34
			70	12	c	35
"	100,000	511.5	50	7	o	34
			70	4	u	35
					r	

Data

- (1) From "Supplementary Model Study of Stilling Basin for Spillway and Sluices, Fort Gibson Dam, Grand River, Oklahoma", U.S.W.E.S. Tech Memo No 2-228, January 1947.

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w/ Taker Dist. 11. 21 Feb 1947. Subj: Fort Gibson Dam. Sluice & Spillway Basin.

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SUPPLEMENTARY MODEL STUDY OF STILLING BASIN FOR SPILLWAY  
AND SLUICES, FORT GIBSON DAM, GRAND RIVER, OKLAHOMA

SYNOPSIS

1. Subsequent to the model tests discussed in Technical Memorandum No. 192-1, entitled "Model Study of Spillway for Fort Gibson Dam, Grand River, Oklahoma," dated 15 January 1943, the plans for the Fort Gibson Project were changed by modification of the spillway and stilling-basin designs and the addition of ten sluices through a portion of the overflow section of the spillway. The modifications to the spillway and stilling basin involved lowering the crest elevation, increasing the length of the spillway and number of gates, and raising the elevation of the stilling basin. Following adoption of these alterations, it was thought desirable to check the adequacy of the structures as revised by means of model tests.

2. Three models of the sluices, spillway and stilling basin were used to determine flow conditions for the revised design. Tests revealed the sufficiency of the revised spillway and stilling basin to pass all spillway flows and combined spillway and sluice flows. Tests also indicated the superiority of a high-level sluice (designated in this report as type 2 sluice) over a low-level sluice discharging at stilling-basin elevation. In either case, however, one sluice operating at full capacity produced high velocities in the exit channel. This condition was alleviated only by lengthening the stilling basin 20 ft. It was also found that basin performance during sluice flow was improved by the use

of training walls to separate that section of the stilling basin into which the sluices discharged from the remainder of the basin width.

## PART I: INTRODUCTION

### Authority

4. Authority to undertake the model studies described in this report was requested by the District Engineer, U. S. Engineer Office, Tulsa, Oklahoma, in a letter, dated 15 November 1945, to the Chief of Engineers through the Division Engineer, Southwestern Division. Authority was granted by the Chief of Engineers in an indorsement, dated 7 December 1945, to the above letter.

### Personnel

5. The model studies were accomplished in the Outlet Works Section of the Structures Branch, Hydraulics Division, U. S. Waterways Experiment Station. Chief of the Hydraulics Division is Mr. E. P. Fortson, Jr., Engineer; Chief of the Structures Branch is Mr. F. R. Brown, Engineer; and Chief of the Outlet Works Section is Mr. T. E. Murphy, Engineer. The Project Engineer in charge of the model studies and preparation of this report was Mr. C. Kestenbaum, Engineer.

6. Mr. D. P. Grosshans, Direct, Engineering Division, Mr. Harold W. Feldt, Chief, Hydraulic Design Section, and Mr. E. C. Franzen, Chief, Structural Design Section, of the Tulsa District Office, visited the Experiment Station in an advisory capacity at intervals during the testing program.

### The Problem

7. A description of the proposed Fort Gibson Dam structures is

contained in Part II of Technical Memorandum No. 192-1, "Model Study of Spillway for Fort Gibson Dam, Grand River, Oklahoma," dated 15 January 1943, which reports the results of tests made on the spillway as originally designed. Subsequent to these studies, details of the spillway were revised by the Tulsa District Office as shown by plate 1 of this report. The tests reported herein were considered desirable after these changes -- listed below -- were made in the original design.

- a. The spillway crest was lowered from elevation 551\* to elevation 547, and its gross length increased from 1430 ft to 1490 ft.
- b. The number and size of spillway-control gates was changed from twenty-four 50-ft-wide by 31-ft-high gates to thirty 40-ft-wide by 35-ft-high gates.
- c. The maximum discharge used as a basis for spillway design was increased from 865,000 cfs at a head of 33 ft to 919,000 cfs at a head of 35 ft.
- d. Ten 5-ft-8-in. by 7-ft sluices through a portion of the overflow section of the spillway were added.
- e. The maximum elevation of the transverse sloped stilling basin was raised from 481 to 485.

Although the spillway crest was lowered and lengthened, the maximum discharge increased, and the stilling-basin elevation raised, all flow phenomena were in such relation that they closely approximated conditions investigated for the original design and reported upon in Technical Memorandum No. 192-1. That is, for equivalent total flows over the spillway, substantially the same relation of existing tailwater depths to those required for a hydraulic jump over a horizontal basin was maintained. Therefore, it was expected that flow conditions in the stilling basin

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\* All elevations in feet referred to mean sea level.

for spillway discharges would be similar to those previously reported upon. However, no tests had been conducted of stilling-basin performance with sluice flow.

#### Purpose of the Model Studies

8. The general purpose of the model studies was to examine the hydraulic performance of the revised stilling basin for the spillway (as modified) and sluices for Fort Gibson Dam, and to determine means of correcting any uneconomic, unsafe, or undesirable conditions found to exist.

#### Description of the Models

9. Three models were used to investigate the hydraulic performance of the revised stilling-basin design: (a) a 1:20-scale sluice model; (b) a 1:20-scale sluice-spillway section model; and (c) a 1:60-scale spillway section model.

- a. 1:20-scale sluice model. There were reproduced in this model two sluices with outlet inverts at the toe of the spillway (elevation 478) and three deflector-type sluices with higher outlet inverts (elevation 498). Both types of sluices were installed to permit simultaneous investigation of alternate designs. Included in the model were the bellmouth sluice intakes, sluice gates, air vents, exit portals, that portion of the spillway face below elevation 521, a section of the stilling basin, and 200 ft of exit channel. The reservoir area was represented by a reinforced concrete headbay. Photograph 1 is a general view of the model.
- b. 1:20-scale sluice-spillway section model. This model (photograph 9) consisted of a 50-ft wide section of the regulating-sluice model containing one deflector-type sluice above which was added a section of the revised spillway including one crest pier and two half crest bays.
- c. 1:60-scale spillway section model. This model was contained in a glass and steel flume (photograph 11) and reproduced a 60-ft-wide section of the spillway and stilling basin,

500 ft of approach channel, and 850 ft of exit channel.  
All piers and sluices were omitted from the spillway.

## PART II: NARRATIVE OF TESTS

Sluice Flow

10. All tests of sluice flow were conducted on a 1:20 scale model (described in paragraph 9a) with the reservoir at power-pool elevation 554 and the tailwater elevations for the resulting discharges set in accordance with the minimum rating curve shown on plate 2. Tests with the type 1 and type 2 sluices were accomplished with 50-ft and 70-ft stilling basins at elevation 478, the elevation thought to be the average at the time these tests were undertaken. Later, however, it appeared that the average elevation was about 481. Accordingly, tests of the modified type 2 sluice design, wherein the elevation of the entire sluice was lowered 5 ft, were conducted with the basin at elevation 481.

Type 1 sluice

11. Description. The type 1 sluice had its entrance invert at elevation 502 and extended horizontally a distance of about 31 ft from the face of the dam and then sloped downward to the toe of the spillway. Details of the type 1 sluice are shown on photograph 2a and plate 3.

12. Results -- 50-ft stilling basin. Photograph 3a shows flow conditions in the stilling basin with a discharge of 1970 cfs through the type 1 sluice. It was observed that the submerged jet issuing from the sluice was confined to a small portion of the basin width and impinged directly on the end sill. A standing wave formed above the end sill and velocities as high as 16 ft per sec passed over the sill

and attacked the floor of the exit channel. A plot of bottom velocities is presented on plate 4.

13. Results -- 70-ft stilling basin. Shown on photograph 3b are flow conditions with the type 1 sluice and 70-ft stilling basin in place. The sluice jet continued unhindered through the stilling basin until it impinged on the end sill, a standing wave formed over the end sill, and velocities as high as 20 ft per sec attacked the floor of the exit channel. These bottom velocities (plate 5) are slightly higher than those observed with the 50-ft basin (plate 4) -- a condition believed attributable to the greater angle of deflection of the sluice jet with the 50-ft basin and the resulting roller action in the vicinity of the end sill. Comparison of photographs 3a and b indicates greater impact on the end sill and a higher standing wave with the shorter apron.

#### Type 2 sluice

14. Description. The type 2 sluice had its entrance invert at elevation 502 and extended horizontally a distance of about 43 ft from the face of the dam and then sloped on a curve downward for a distance of 4 ft in about 25 ft. This type sluice was designed to discharge on or near the surface of the tailwater. The exit portal consisted of flared sidewalls and a tetrahedral deflector on a horizontal floor at elevation 498. Details of the type 2 sluice are shown on photograph 2b and plate 6.

15. Results -- 50-ft stilling basin. The deflector type outlet portal spread the flow issuing from the sluice into a thin sheet of water of considerable width. With only one sluice in operation, the sheet of water from the sluice entered the tailwater just upstream from

the end sill (photograph 4a) and the cushioning effect of the tailwater was not sufficient to prevent velocities as high as 20 ft per sec from passing over the end sill and attacking the exit channel. A plot of bottom velocities is shown on plate 7. When tested with a sand bed below the end sill, the bed was eroded to a depth of 8 ft below the top of the end sill. As shown on plate 8, bed material from the exit channel was swept upstream on each side of the area of discharge and was deposited on the apron. With three model sluices operating and the tailwater set at an elevation representing discharge from all ten prototype sluices, flow conditions were good (see photograph 4b). Maximum bottom velocities of 14 ft per sec obtained in the exit channel and scour tests indicated erosion to be slight. Plates 9 and 10 present velocity and scour data for the condition of all sluices in operation. With the tailwater set at an elevation representing a discharge of 100,000 cfs (bankful capacity), discharge from the sluices appeared to be partially submerged. However, bottom velocities in the exit channel did not exceed 6 ft per sec. See photograph 4c and plate 11.

16. Results -- 70-ft stilling basin. Flow conditions with the type 2 sluice and a 70-ft stilling basin are shown by photographs 5a, b, and c. Comparison of these photographs with photographs 4a, b, and c reveals similar conditions for both stilling basins. However, the additional 20 ft of stilling-basin length caused some dissipation of energy before flow passed over the end sill and into the exit channel. As a result, bottom velocities and erosion tendencies in the exit channel in practically every instance were reduced. Compare plates 12 to 16 with plates 7 to 11.

Modified type 2 sluice

17. Description. The modified type 2 sluice was identical to the type 2 sluice except that its elevation was lowered 5 ft in an attempt to shorten the trajectory of the issuing sluice flow and thus confine all turbulent flow to the stilling-basin area. Therefore, the entrance invert was at elevation 497 instead of 502, and its outlet invert was at elevation 493 instead of 498. For the tests with the modified type 2 sluice the 50-ft stilling basin was raised to elevation 481, average stilling-basin elevation. This elevation was 3 ft higher than the elevation of the stilling-basin floor with which the type 2 sluice was tested and which was thought to be average at that time.

18. Results. Photographs 6a, b, and c show action in the stilling basin produced by flow from the modified type 2 sluice. The lowering of the sluice did not appear to affect the length of the trajectory of the issuing jet. This is attributed to the extra 5 ft of head on the sluice which resulted from lowering the elevation. With one sluice in operation, modification of the sluice design had little effect on the magnitude of velocities in the exit channel, although the depth of erosion was slightly less. For comparison of velocity and scour results with those obtained with the type 2 sluice, see plates 7, 8, 17, and 18. With three sluices in operation, performance of the modified type 2 sluice was approximately equal to that of the original type 2 sluice with respect to both velocities and erosion tendencies. Compare plates 9 to 11 with plates 19 to 21.

Training walls

19. Description. Tests were conducted with a training wall

installed in the stilling basin (photograph 7) to furnish indications of the effect of separating, by such a wall, the 600 ft of stilling basin into which the sluices discharged from the remaining 890 ft of stilling basin. It was hoped that the use of walls would improve basin conditions under sluice flow by eliminating eddy action. Only one wall was added to the model; it extended 10 ft downstream from the end sill and rose to elevation 500.

20. Results. Flow conditions in the stilling basin with the training wall in place are shown by photographs 8a, b, and c. As planned, the training wall prevented the formation of an eddy in the unused part of the stilling basin. This is well illustrated by a comparison of photographs 6a and 8a. Without the training wall installed (photograph 6b), sluice flow was confined to a small portion of the basin width adjacent to the left wall of the model; the use of the training wall (photograph 8a) increased the spread of the sluice discharge. With one sluice in operation little change was produced in velocities or erosion tendencies. Compare plates 22 and 23 with plates 17 and 18. However, with three sluices in operation the training wall caused a decrease in bottom velocities and a lessening of erosion tendencies. Compare plates 24 to 26 with plates 19 to 21.

#### Spillway and Sluice Flow

21. In order to study the effect of spillway discharge on sluice capacity, and the effectiveness of the stilling basin in dissipating the energy of combined spillway and sluice flow, a 50-ft-wide section of spillway crest was constructed above one of the sluices. This model,

constructed to an undistorted scale ratio of 1:20, is described in paragraph 9b and shown by photograph 9. Of importance in the testing program were stilling-basin conditions for a discharge of 100,000 cfs, which is bankfull capacity of the Grand River. The plan of operation of the reservoir calls for the release of water through the sluices and over the spillway until a flow of 100,000 cfs is reached, after which operation of the spillway gates would limit the flow to this amount.

#### Effect of spillway flow on sluice capacity

22. The effect of spillway flow on sluice capacity was determined in the following manner.

a. A discharge of 3333 cfs representing a discharge for the entire structure of approximately 100,000 cfs, was introduced into the reservoir and allowed to flow freely over the spillway section and through the sluice. The tailwater elevation was lowered a sufficient amount to permit free discharge from the sluice. The water surface in the reservoir rose to elevation 552.8.

b. The sluice gate was closed and the reservoir pool elevation set at 552.8. The discharge over the 50-ft spillway section was measured and found to be 1825 cfs.

c. Then the spillway was blocked, the sluice gate opened, and the reservoir pool elevation again set at 552.8. Flow through the sluice was measured and found to be 1695 cfs.

Thus, at a pool elevation of 552.8 the combined spillway-sluice discharge was 3333 cfs while the sum of the separate spillway and sluice discharges was 3520 cfs. Since sluice flow can not affect spillway discharge, it is concluded that the capacity of the sluices would be

reduced by about eleven per cent when operated in conjunction with the spillway at a combined discharge of 100,000 cfs.

#### Stilling-basin action

23. Photographs 10a and b show flow conditions in the 50-ft and 70-ft stilling basins and exit channel for a combined spillway sluice discharge representing 100,000 cfs. Stilling action appeared satisfactory and velocities over the bed of the exit channel did not exceed 4 ft per sec (plates 27 and 28). The only evidence of scouring tendencies occurred along the fixed walls of the flume (plates 29 and 30).

#### Spillway Flow

24. In order to check spillway performance at the maximum stilling-basin elevation of 485, a 1:60-scale section model was constructed as described in paragraph 9c and shown by photograph 11. Two stilling basins, one 50 ft long and the other 70 ft long, were investigated.

25. Results. Tests revealed that flow characteristics in the 50-ft and 70-ft stilling basins were similar. Flow conditions shown by photographs 12a, b, and c and 13a, b, and c, and water-surface profiles shown on plates 31, 32, and 33 indicate that roller action was maintained within the stilling basin for all conditions of flow despite the high basin elevation. The tailwater elevation had to be lowered as shown in the following table before spray action occurred.

<u>Discharge</u>	<u>Stilling Basin Length</u>	
	<u>50-Ft</u>	<u>70-Ft</u>
1,020,000	7.7 ft	6.7 ft
300,000	17.1 ft	13.8 ft
100,000	-----	-----

It may be noted that the tailwater elevation could be reduced more on the 50-ft basin than on the 70-ft basin before spray action occurred. For discharges in excess of 100,000 cfs the two stilling basins produced bottom velocities in the exit channel of approximately the same magnitude. At a discharge of 100,000 cfs, however, bottom velocities in the exit channel below the 50-ft basin (plate 34) were slightly greater than those recorded below the 70-ft basin (plate 35). In neither case were the velocities considered excessive.

## PART III: CONCLUSIONS AND RECOMMENDATIONS

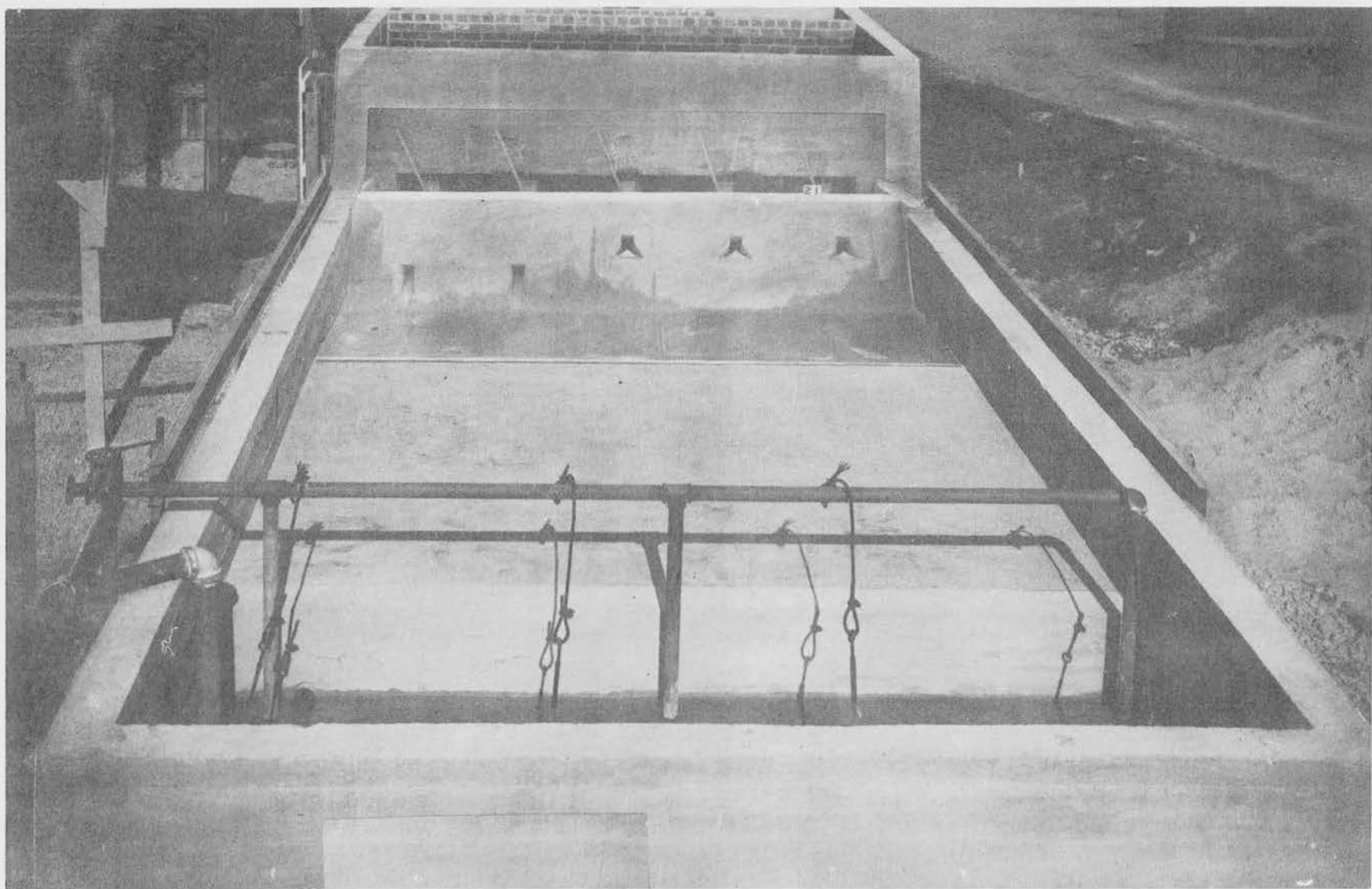
26. The model tests demonstrated conclusively the superiority of the deflector-type sluice exit portal over the sluice exit portal with its invert at stilling basin elevation in dissipation of energy. Flow from the deflector-type exit portal was dispersed into a thin sheet, whereas flow from the exit portal with its invert at the toe of the spillway emerged in a concentrated jet and continued unchecked across the basin and impinged on the end sill with considerable force.

27. It is recommended that the type 2 sluice with the walls of the outlet portal modified as described below be constructed in the prototype. It is proposed that the sidewalls of the outlet portal be warped surfaces consisting of straight elements lying in vertical planes normal to the horizontal extension of the conduit axis. The floor plan is to be the lower guide for the elements, while the upper guide is to be composed of two tangent lines extended from the right and left upper corners of the sluice proper. Tests conducted subsequent to the Fort Gibson tests on similar sluice models have indicated that such modification of the outlet portal sidewalls will not materially affect the spread of the jet nor flow conditions in the stilling basin, and will improve pressure conditions within the outlet portal.

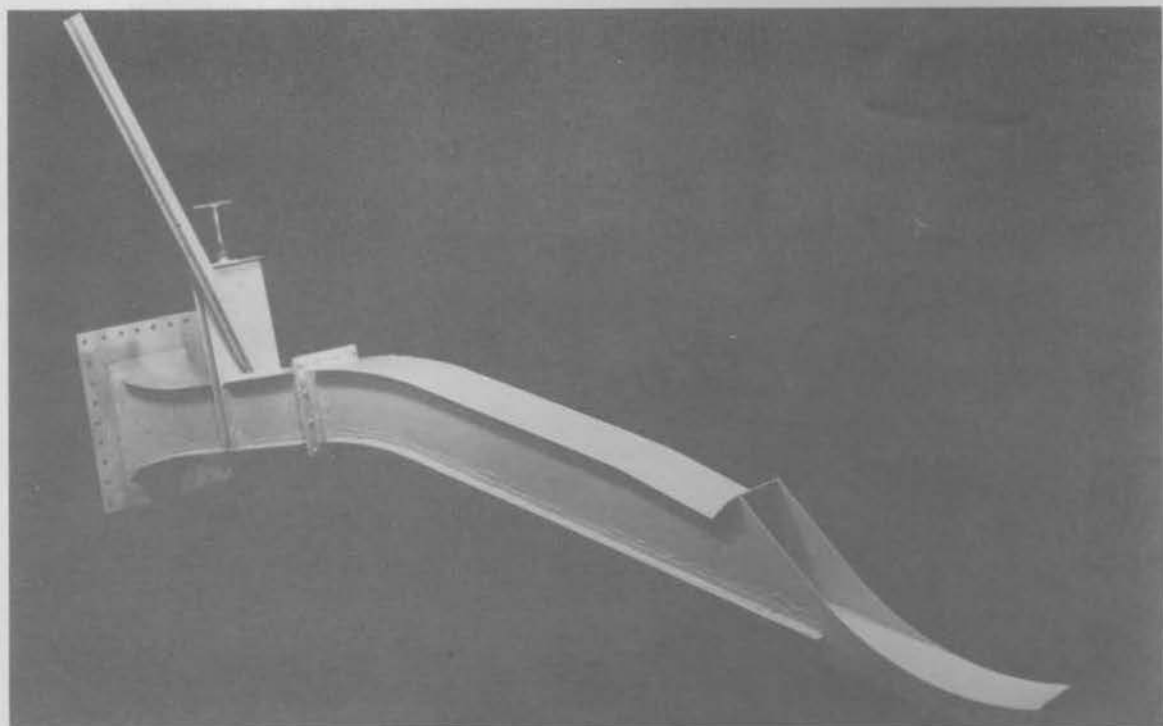
28. Since the 50-ft stilling basin did not satisfactorily dissipate the energy from one sluice operating at full capacity, it is recommended that either a 70-ft stilling basin be installed below the sluices or an operation schedule be established whereby several sluices will be operated at partial gate openings rather than one sluice at full

gate opening. For best basin performance under sluice discharge it is further recommended that training walls be used to separate the 600-ft-width of stilling basin into which the sluices discharge from the remaining 890-ft-width of stilling basin. These training walls will improve basin action under sluice flow by eliminating eddy action in the unused portion of the stilling basin. If economically feasible, it is recommended that the ten sluices be separated into batteries of five sluices each by the addition of another training wall. This would permit more symmetrical operation of the sluices, thus reducing eddy action and the tendency to wash gravel and abrasive material into the stilling basin.

## PHOTOGRAPHS

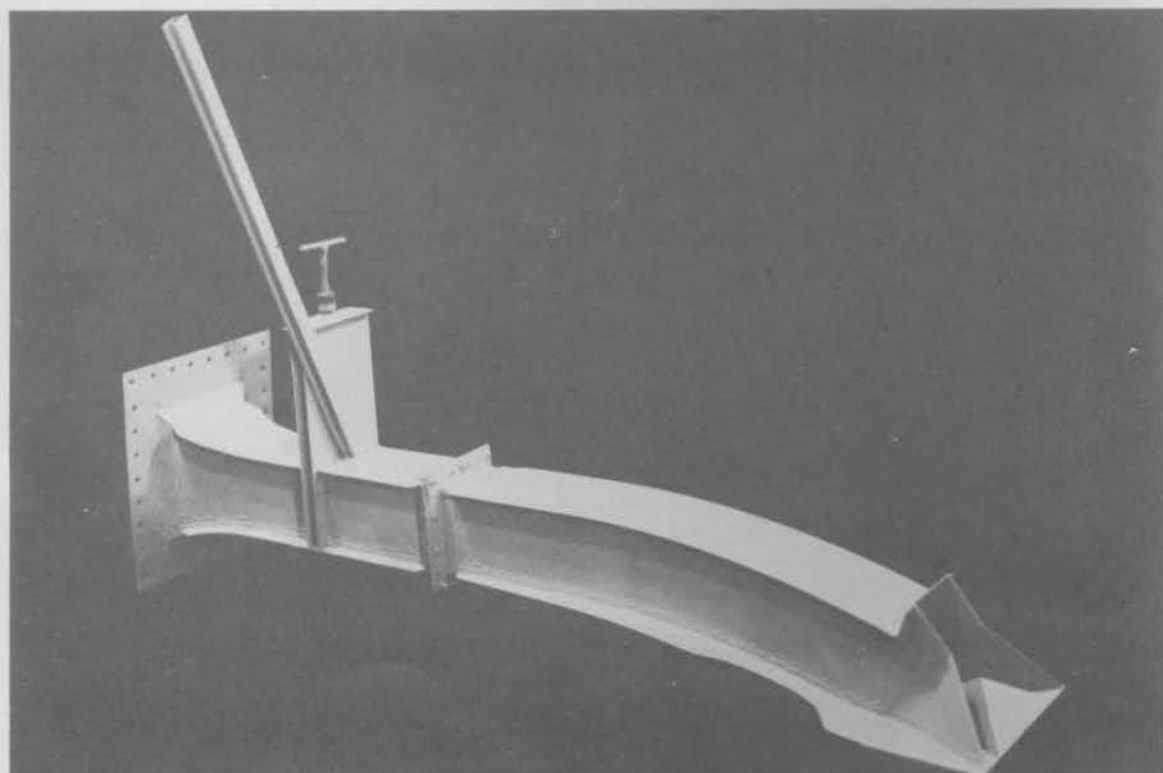


1:20-scale sluice model showing both type sluices



a.

Type 1



b.

Type 2

Sluice designs



a. Length of basin 50 ft



b. Length of basin 70 ft

Flow conditions in stilling basin with one sluice in operation  
Type 1 sluice design; Discharge 1970 cfs; Tailwater elev 491.3



a. One sluice in operation  
Discharge 1,720 cfs Tailwater elev 491.3



b. All sluices in operation  
Discharge 16,950 cfs Tailwater elev 496.7



c. All sluices in operation  
Discharge 16,000 cfs Tailwater elev 511.5

Flow conditions in stilling basin for  
various sluice discharges

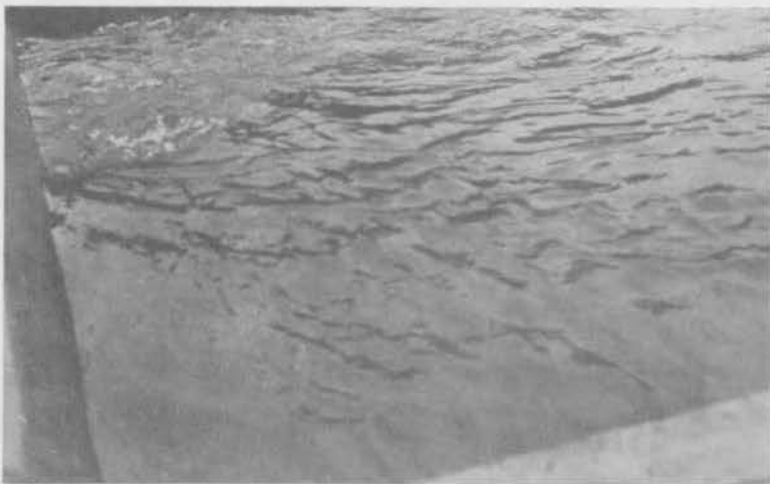
Type 2 design sluice  
Elevation of basin 478  
Length of basin 50 ft



a. One sluice in operation  
Discharge 1,720 cfs Tailwater elev 491.3



b. All sluices in operation  
Discharge 16,950 cfs Tailwater elev 496.7



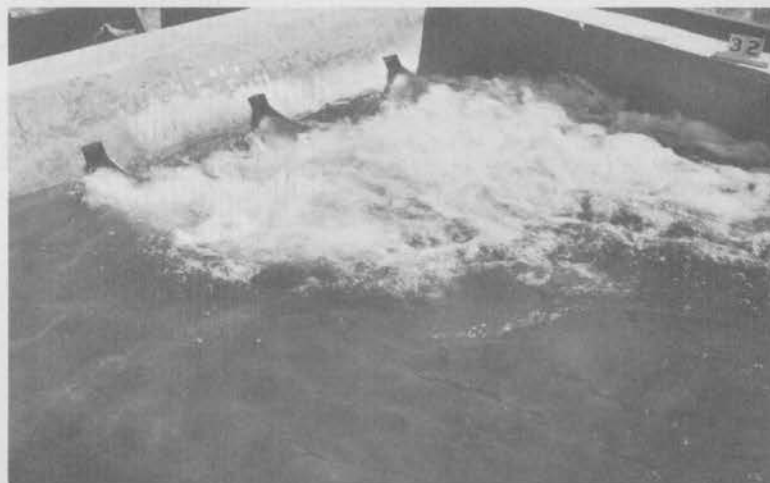
c. All sluices in operation  
Discharge 16,000 cfs Tailwater elev 511.5

Flow conditions in stilling basin for  
various sluice discharges

Type 2 design sluice  
Elevation of basin 478  
Length of basin 70 ft



a. One sluice in operation  
Discharge 1,750 cfs Tailwater elev 491.3



b. All sluices in operation  
Discharge 17,750 cfs Tailwater elev 496.7



c. All sluices in operation  
Discharge 15,400 cfs Tailwater elev 511.5

Flow conditions in stilling basin for  
various sluice discharges

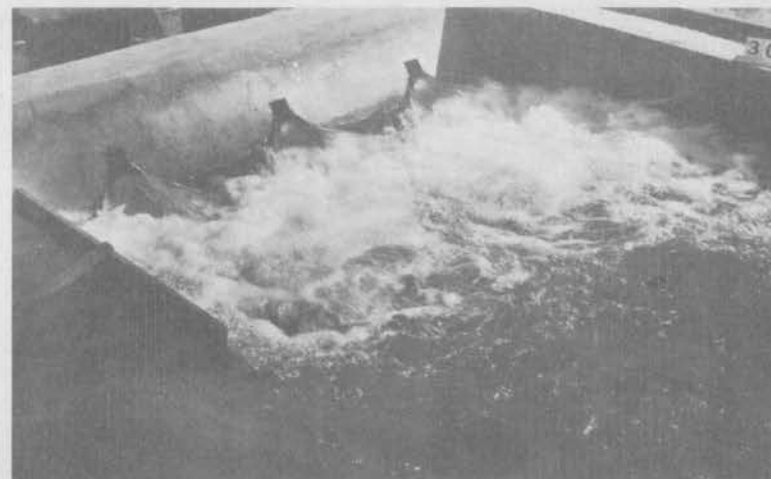
Modified type 2 sluice design  
Elevation of basin 481  
Length of basin 50 ft



1:20-scale sluice model with training wall installed in the stilling basin  
Sluice exit portal elev 493      Length of basin 50 ft      Stilling basin elev 481



a. One sluice in operation  
Discharge 1,750 cfs Tailwater elev 491.3



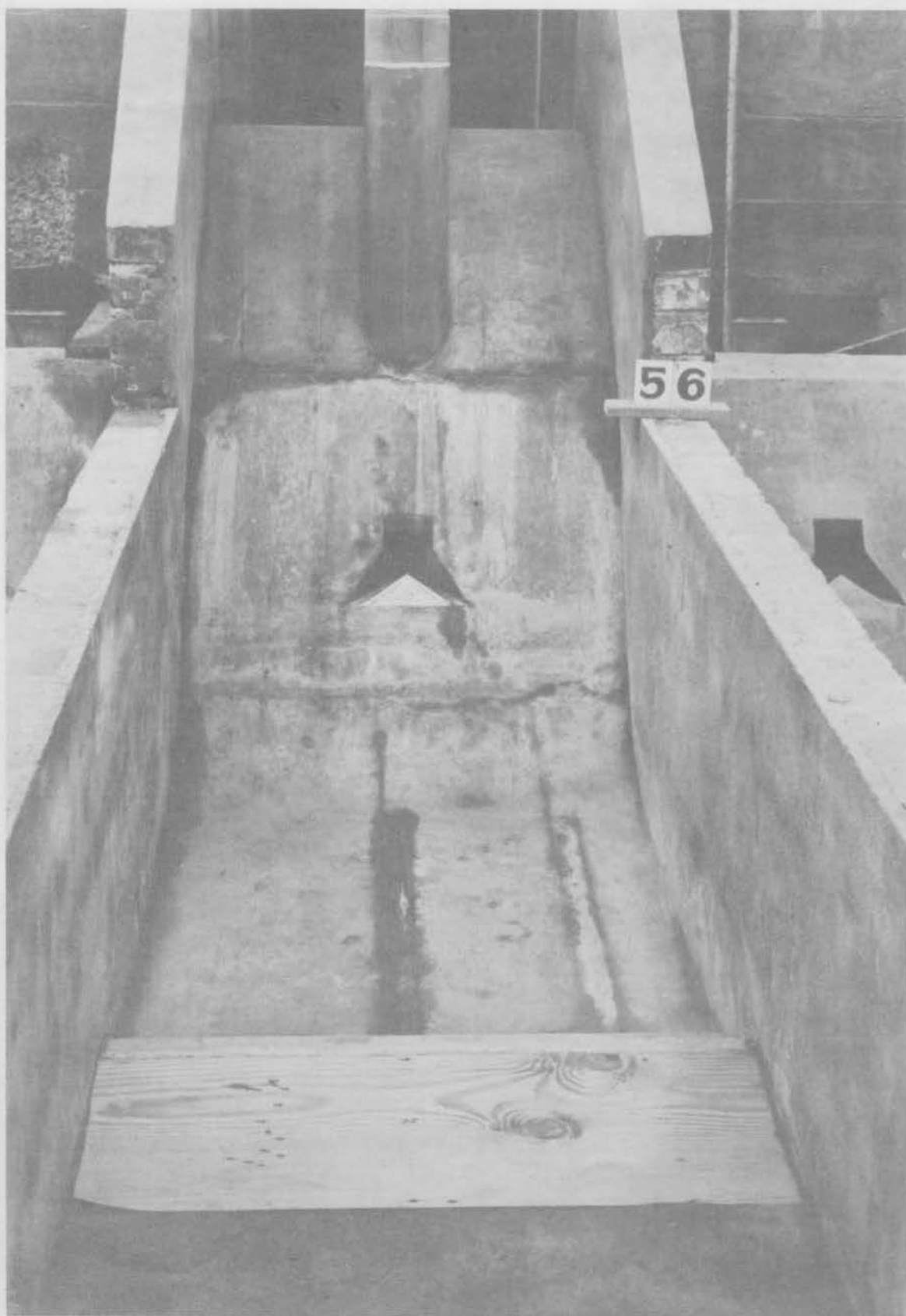
b. All sluices in operation  
Discharge 17,750 cfs Tailwater elev 496.7



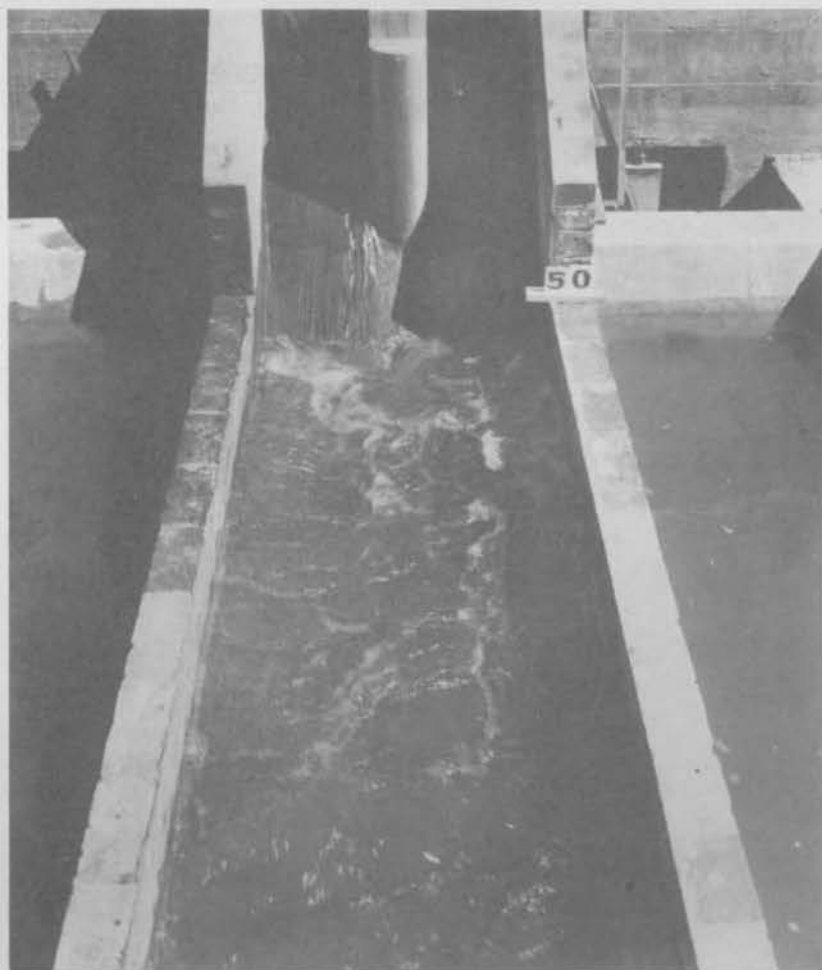
c. All sluices in operation  
Discharge 15,400 cfs Tailwater elev 511.5

Flow conditions in stilling basin for  
various sluice discharges

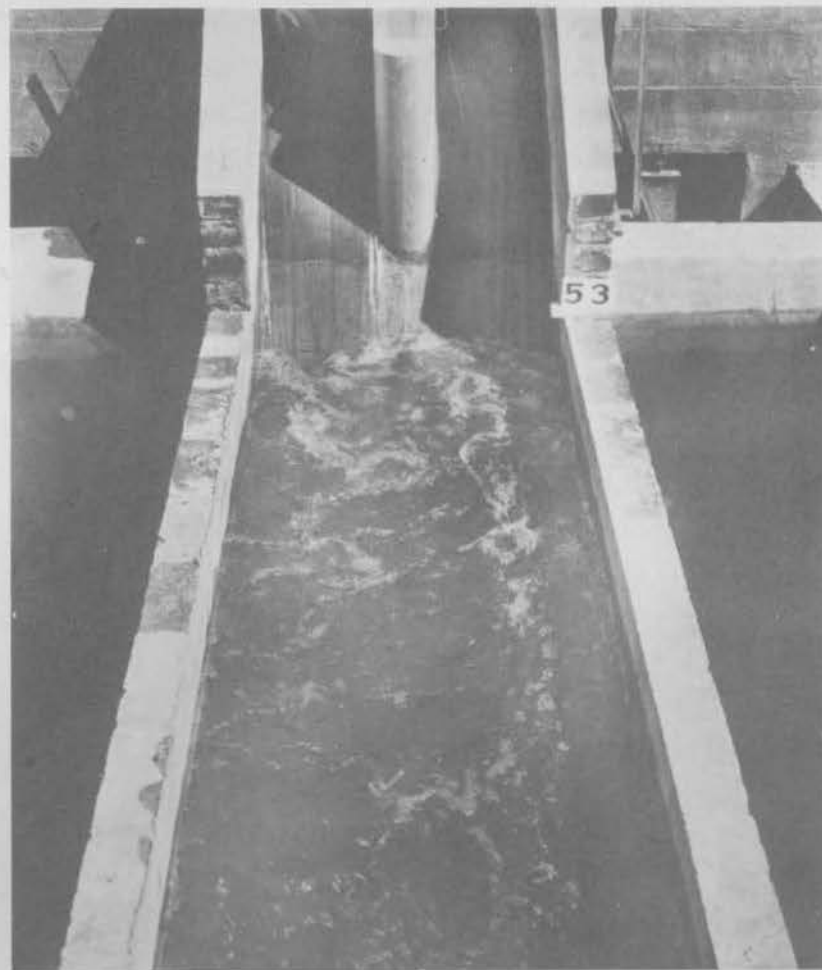
Modified type 2 sluice design  
Elevation of basin 481  
Length of basin 50 ft  
Training wall installed



General view of spillway-sluice section model

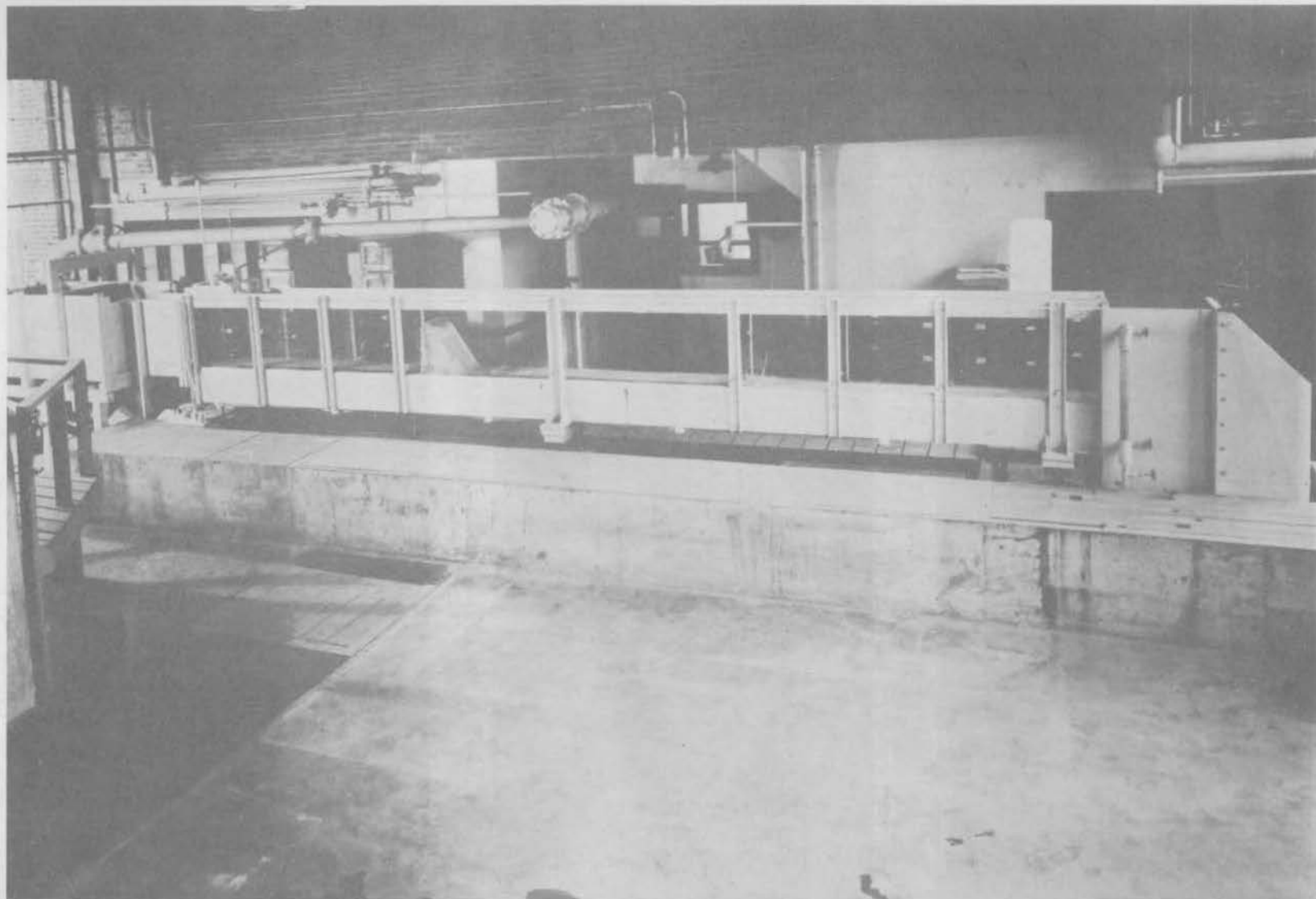


a. Length of stilling basin 50 ft

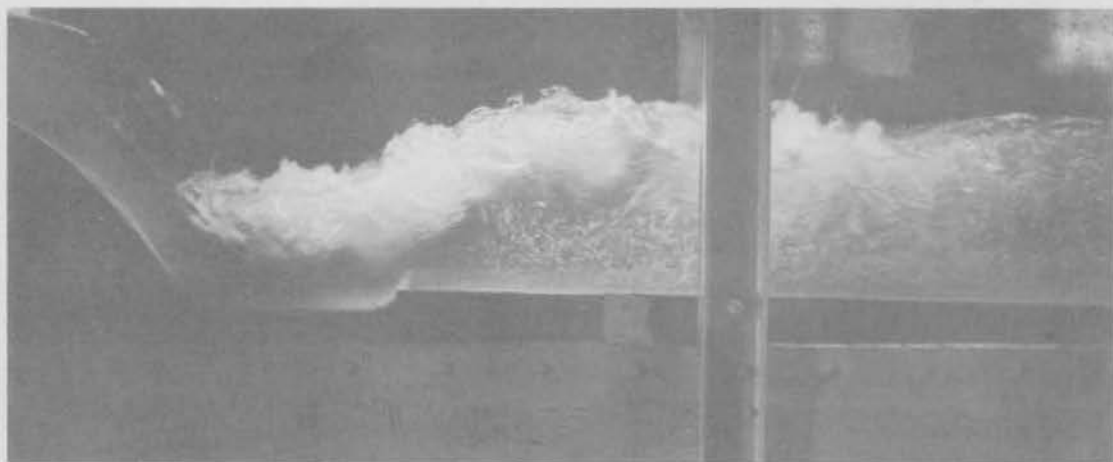


b. Length of stilling basin 70 ft

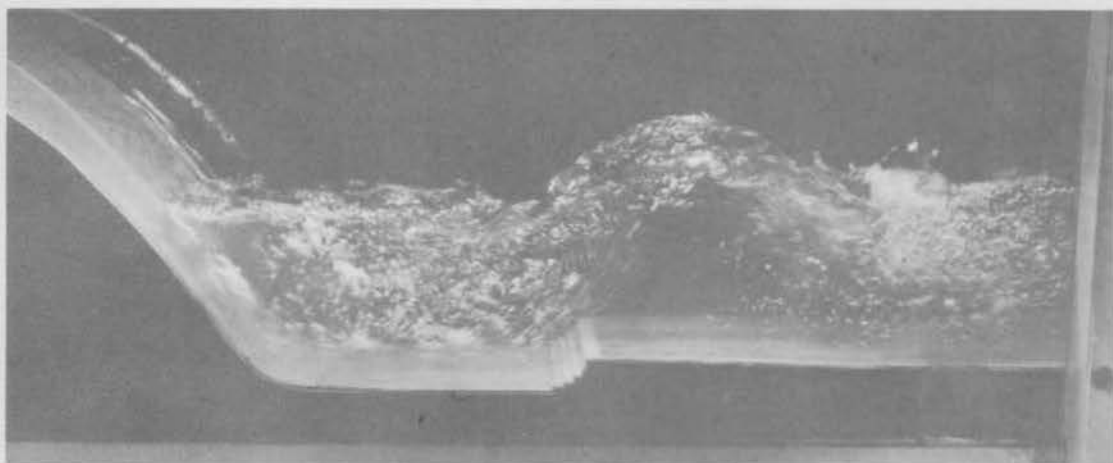
Combined spillway and sluice discharge 100,000 cfs  
Tailwater elev 511.5      Basin elev 481



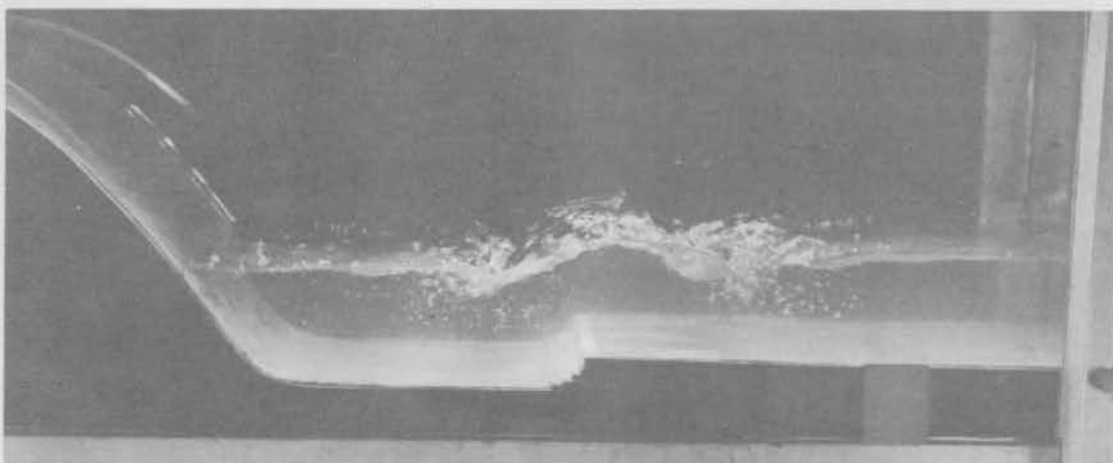
General view of spillway section model



a. Discharge 1,020,000 cfs Tailwater elev 545.5

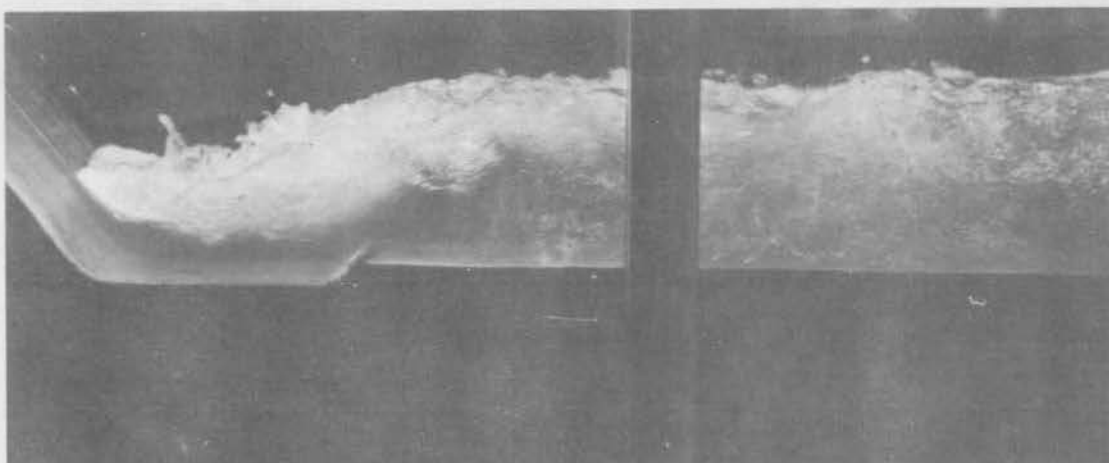


b. Discharge 300,000 cfs Tailwater elev 525.8

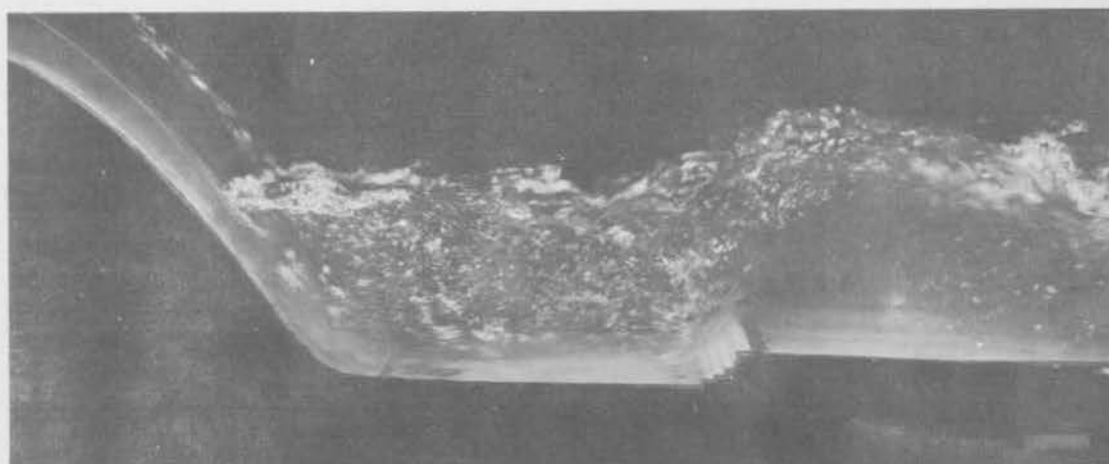


c. Discharge 100,000 cfs Tailwater elev 511.5

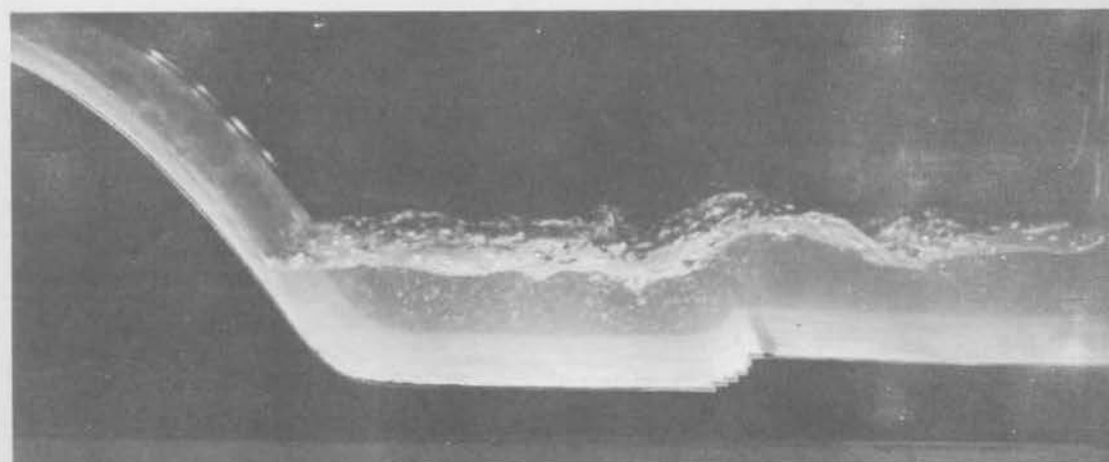
Flow conditions in stilling basin for various spillway discharges  
 Elev of basin 485 Length of basin 50 ft



a. Discharge 1,020,000 cfs Tailwater elev 545.5



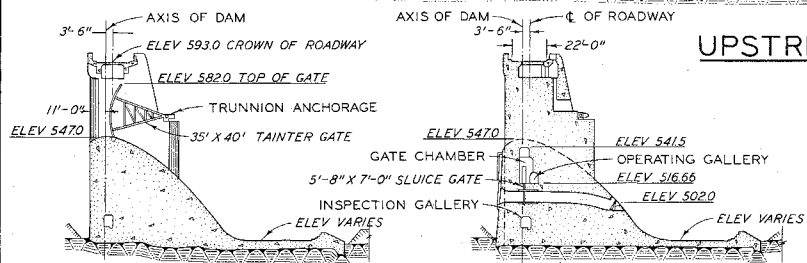
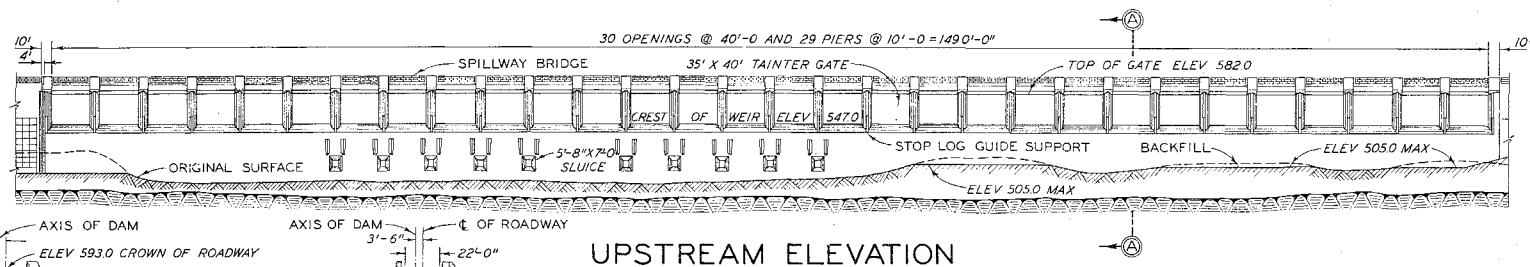
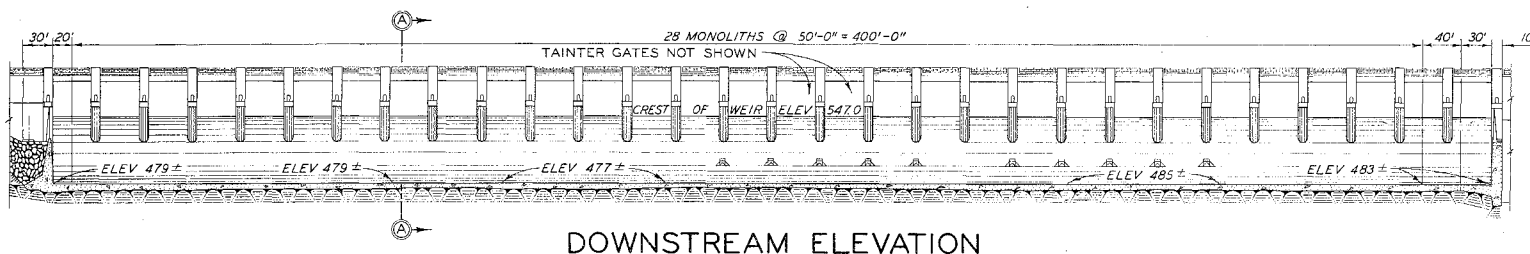
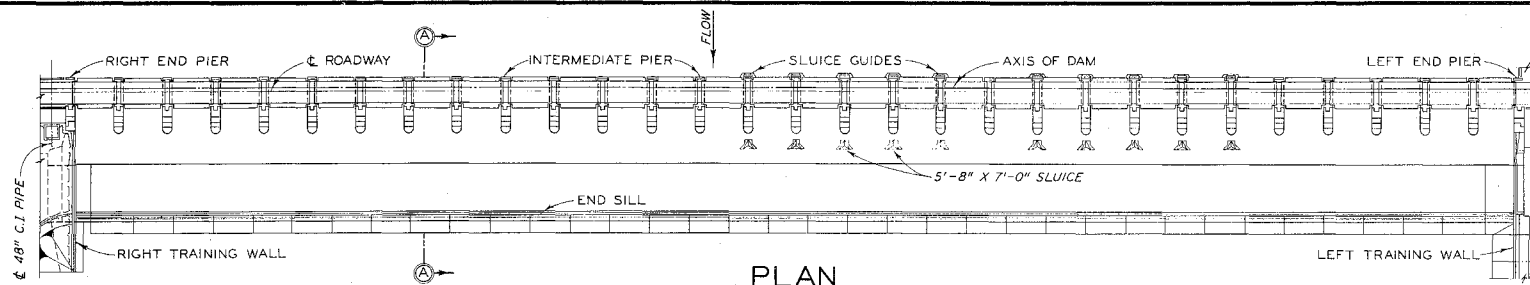
b. Discharge 300,000 cfs Tailwater elev 525.8



c. Discharge 100,000 cfs Tailwater elev 511.5

Flow conditions in stilling basin for various spillway discharges  
 Elev of basin 485 Length of basin 70 ft

## PLATES

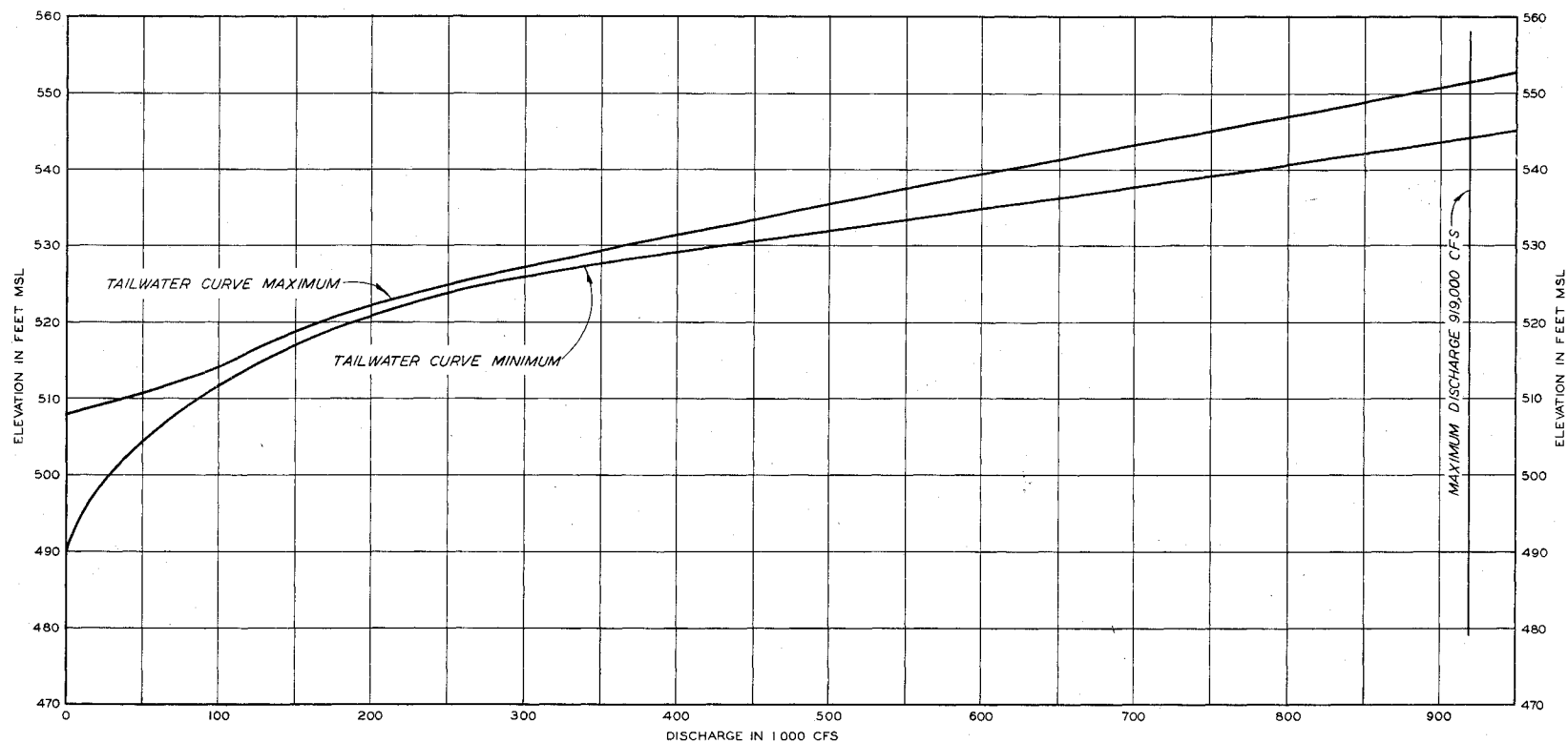


SCALE IN FEET  
30 0 30 60 90

SCALE IN FEET  
30 0 30 60 90

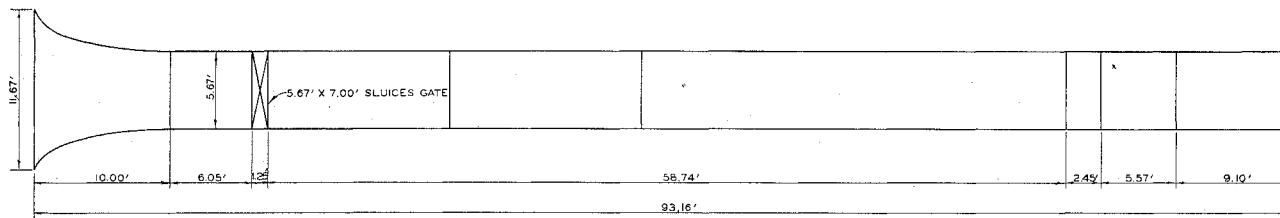
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
PLAN, ELEVATIONS AND SECTIONS

SCALE IN FEET  
50 0 50 100 150 200 250 300

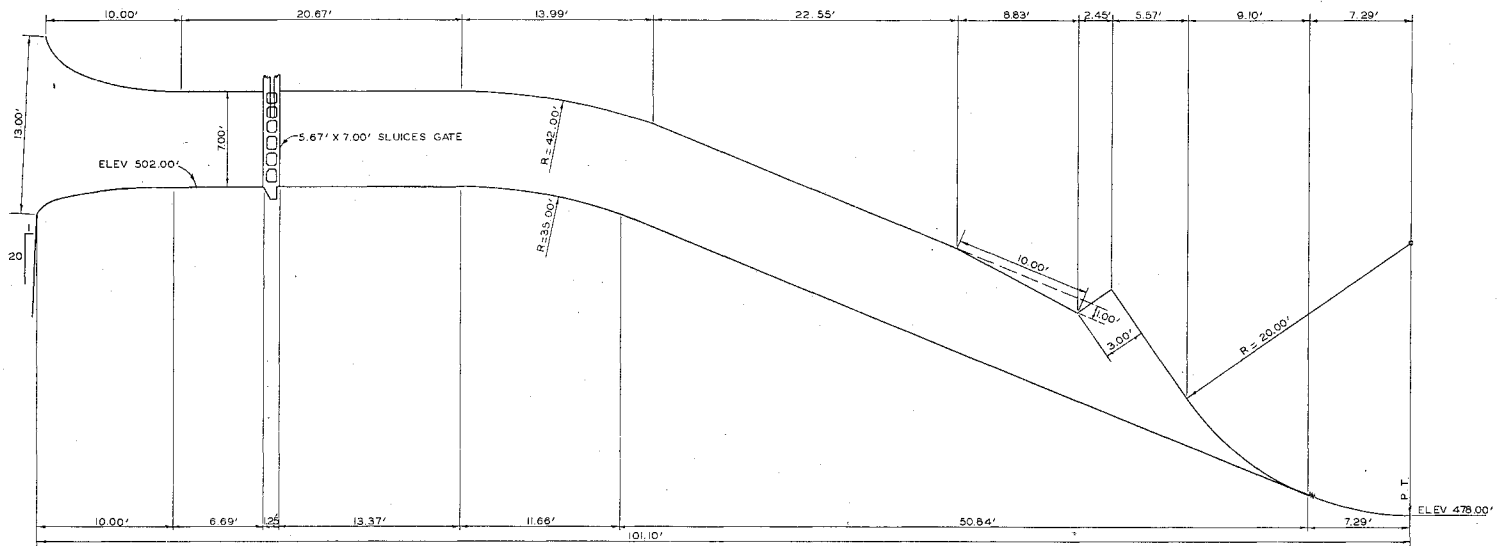


NOTE: DIFFERENCE IN TAILWATER CURVES  
DUE TO BACKWATER EFFECT FROM  
ARKANSAS RIVER.

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
TAILWATER RATING CURVES

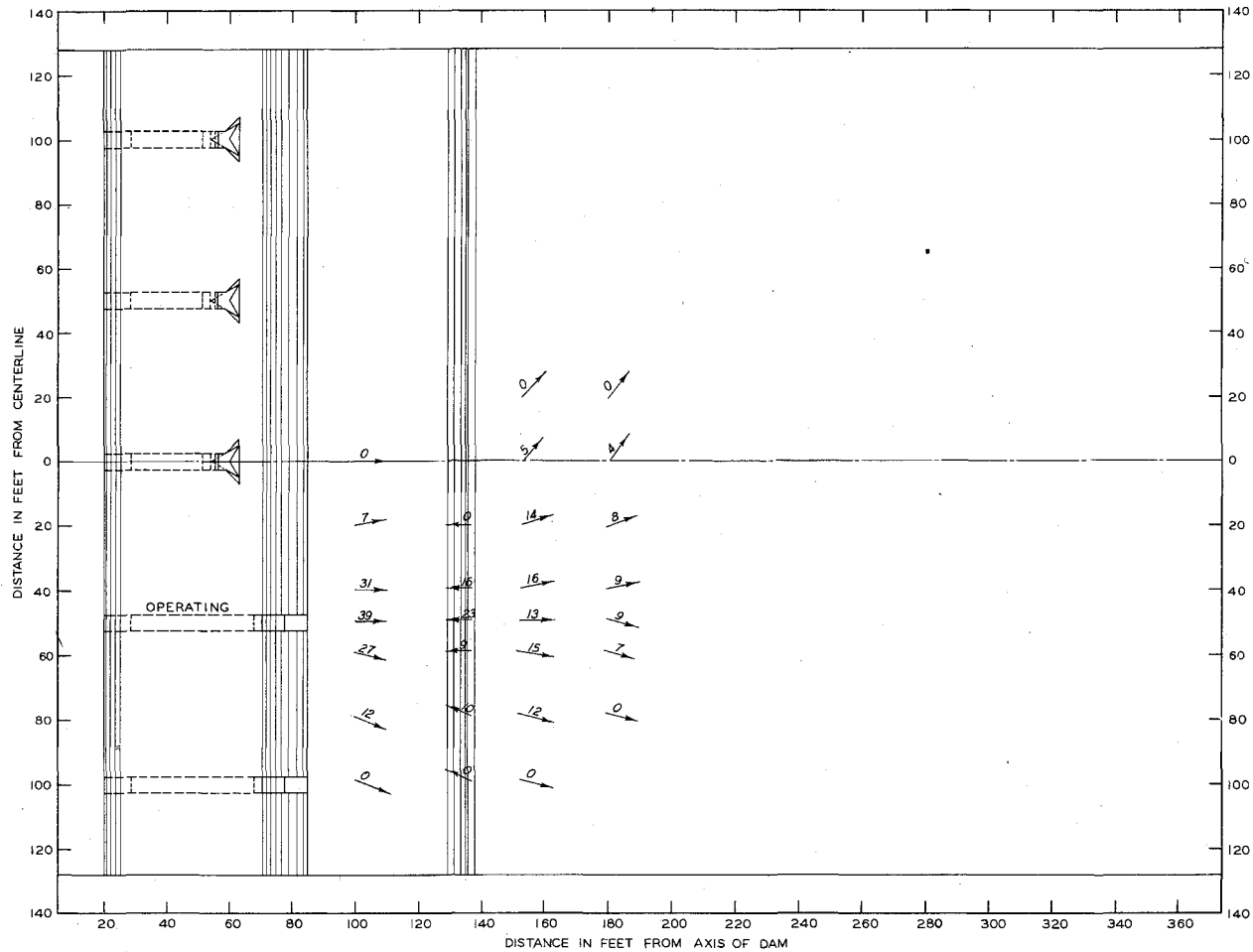


PLAN



ELEVATION

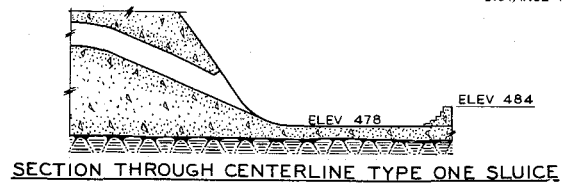
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**TYPE I SLUICE**



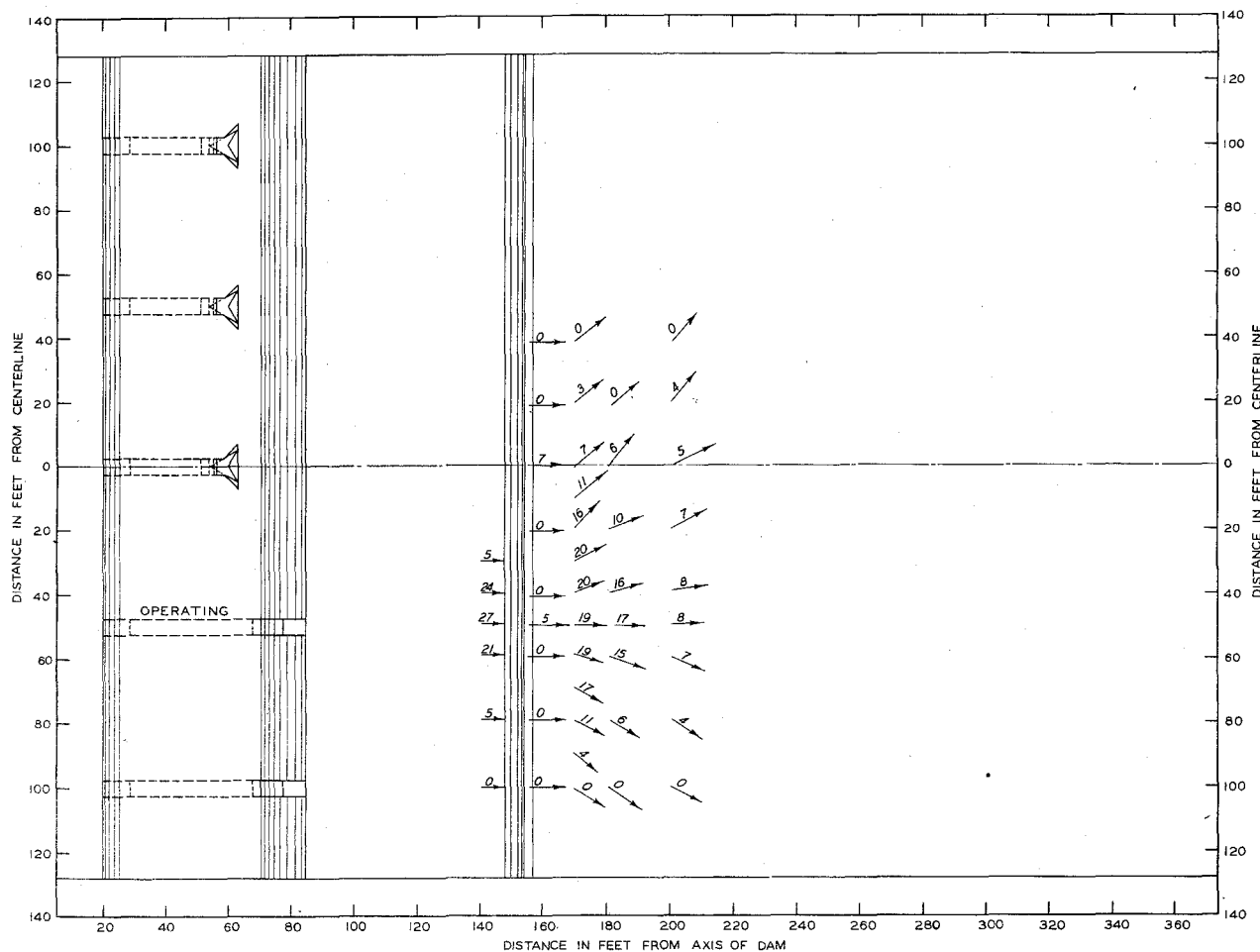
TEST CONDITIONS

DISCHARGE	1,970 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 484.0.



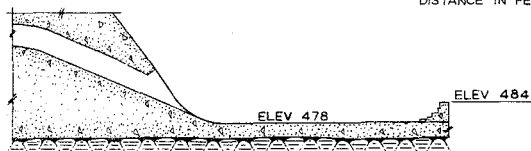
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



# TEST CONDITIONS

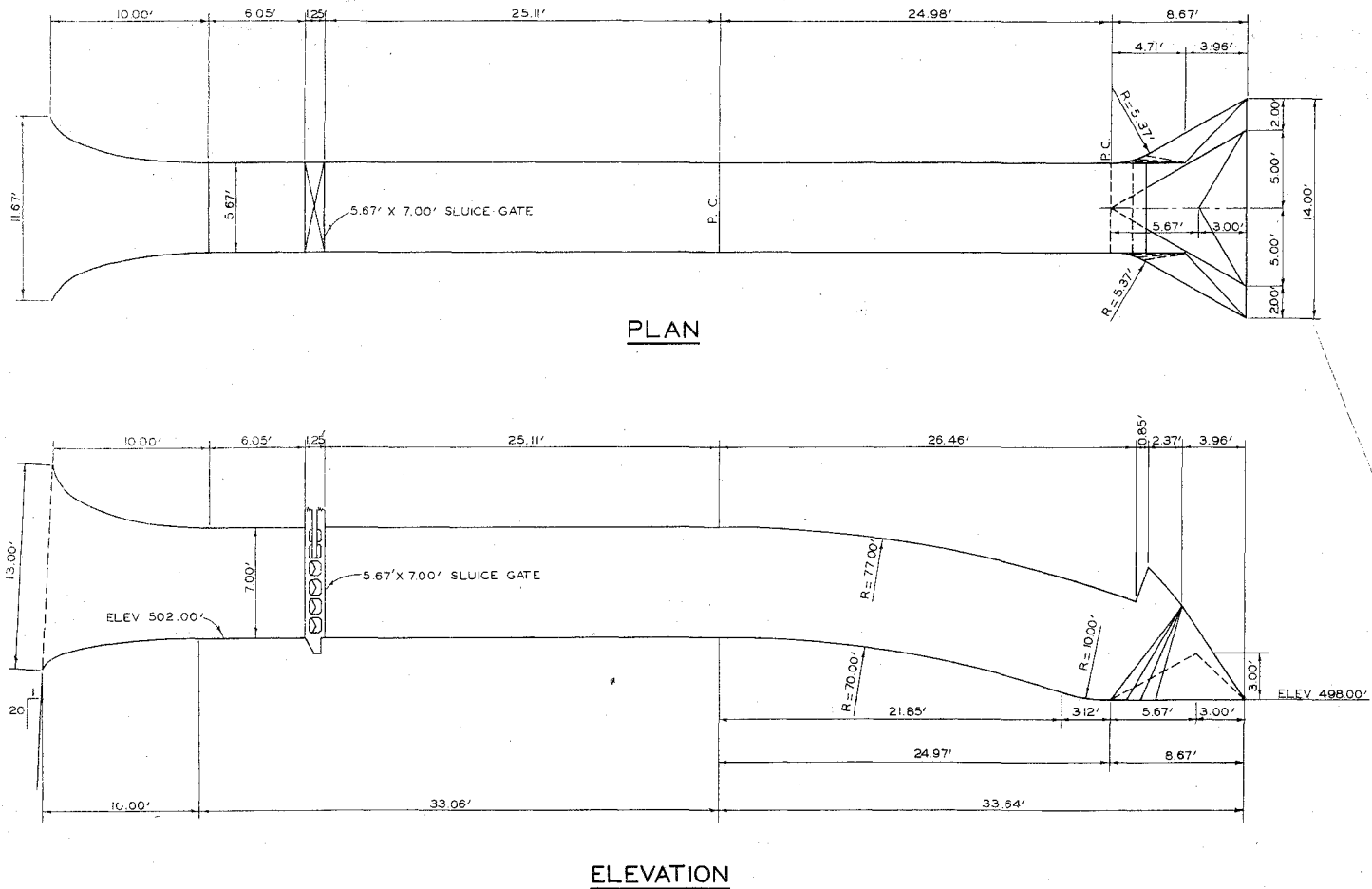
DISCHARGE	1,970 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	70 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 484.0.

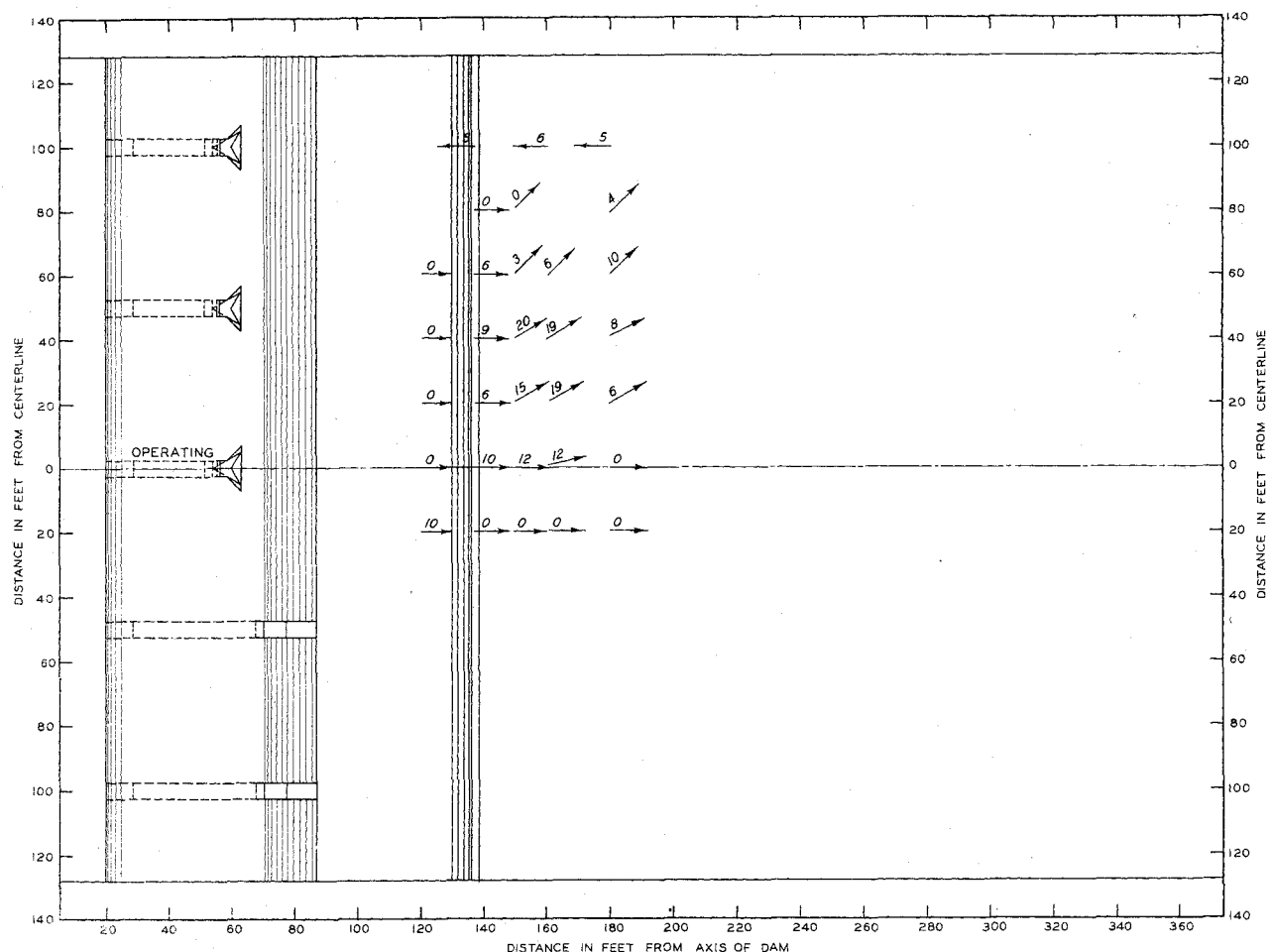


SECTION THROUGH CENTERLINE TYPE ONE SLUICE

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



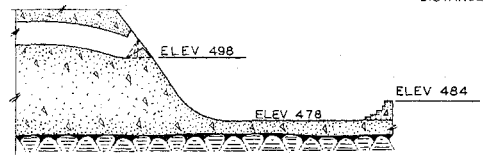
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**TYPE 2 SLUICE**



### TEST CONDITIONS

DISCHARGE	1,720 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEVATION 484.0



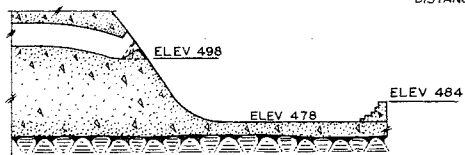
SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**

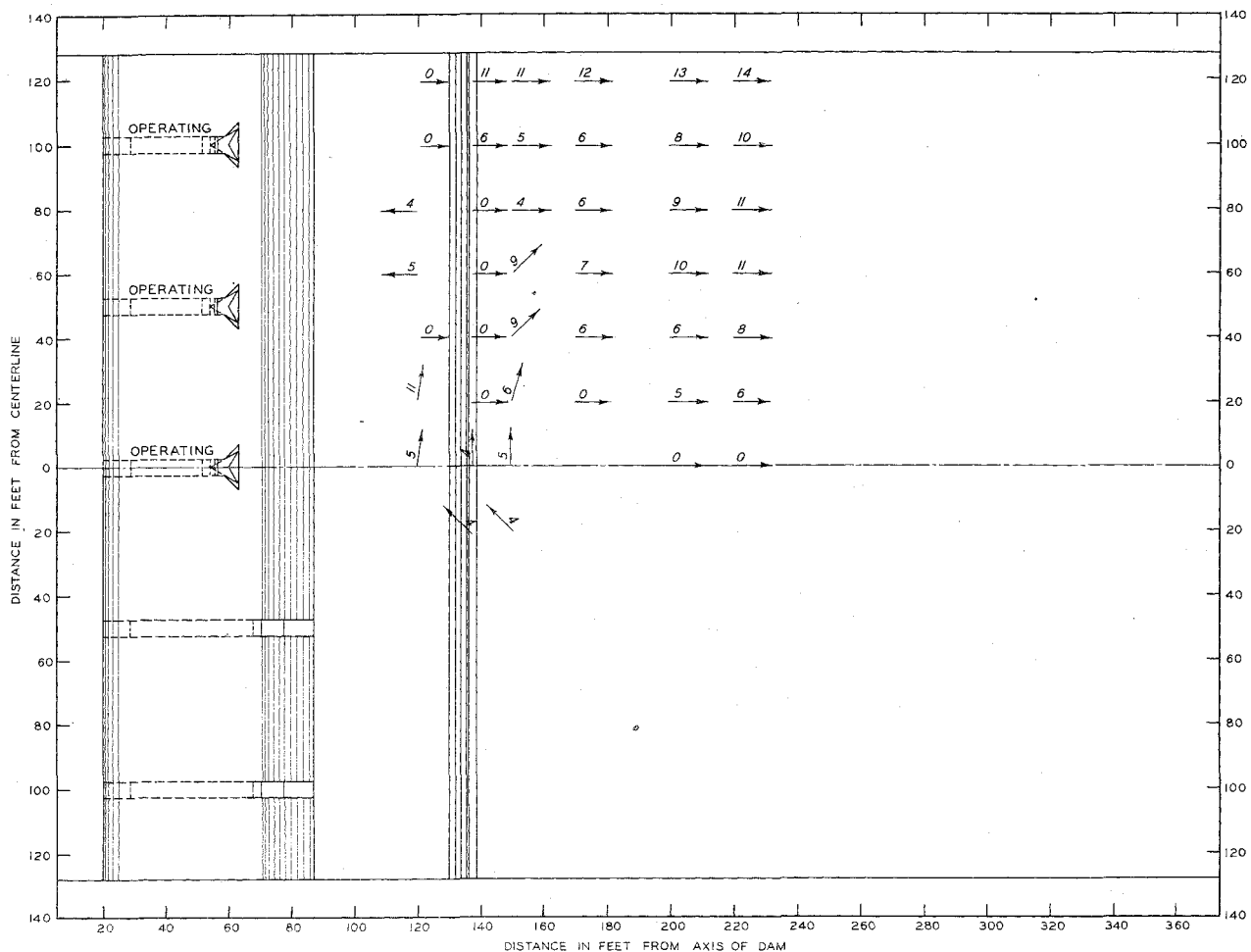
### TEST CONDITIONS

DISCHARGE	1,720 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 484.0.



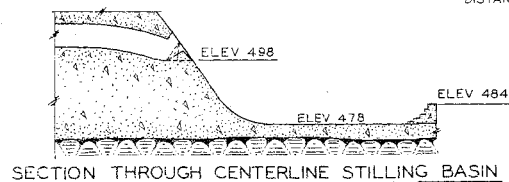
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
SCOUR PATTERN



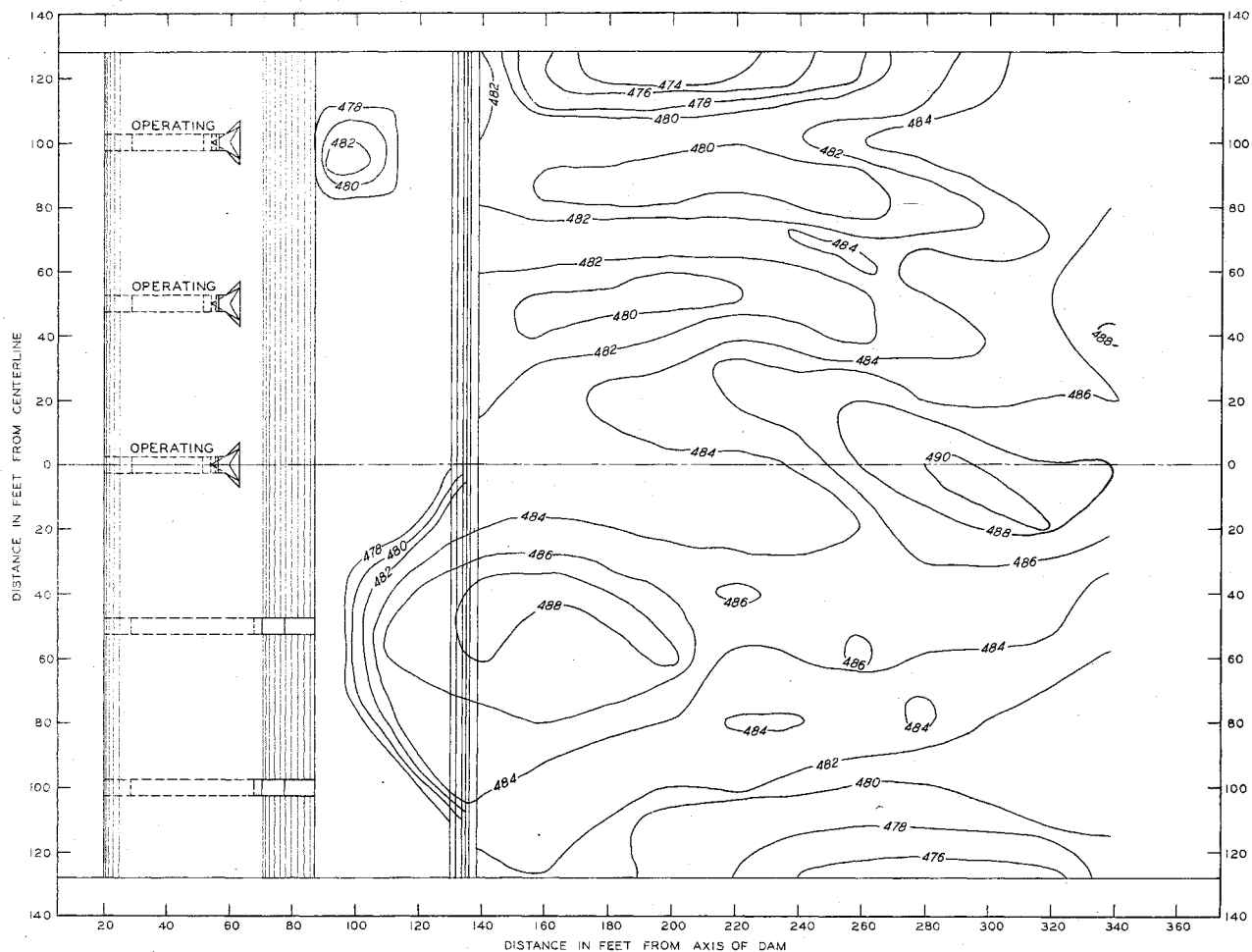
#### TEST CONDITIONS

DISCHARGE	16,933 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEVATION 484.0.



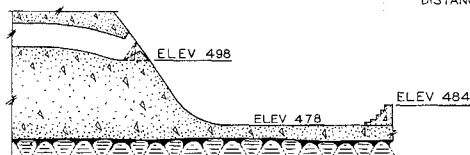
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



TEST CONDITIONS

DISCHARGE	16,933 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	50 FT

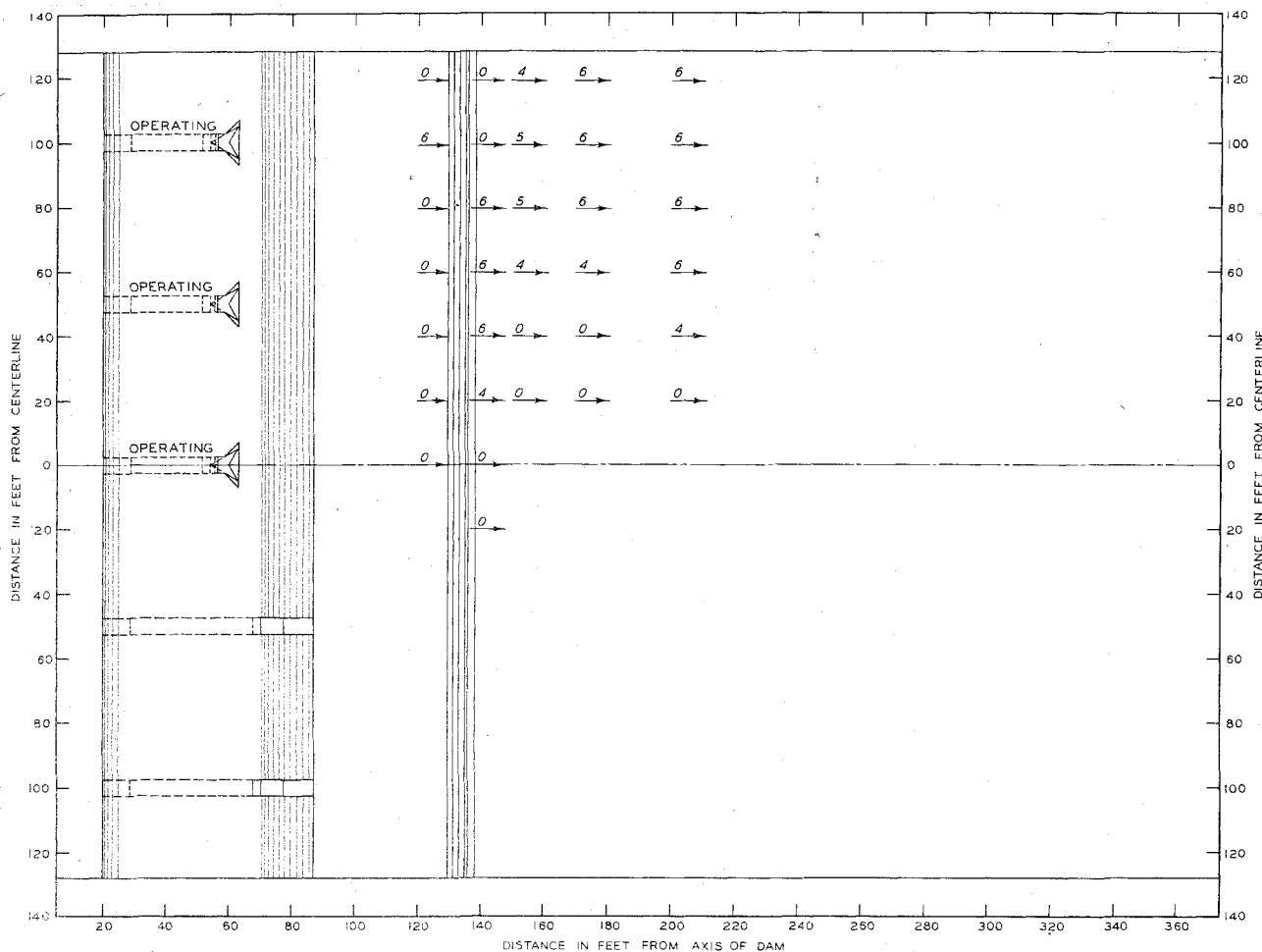
NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 484.0.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA

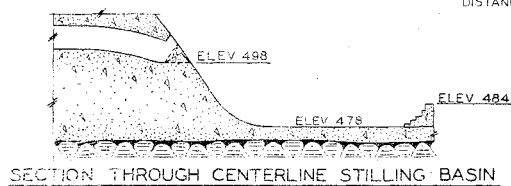
**SCOUR PATTERN**



#### TEST CONDITIONS

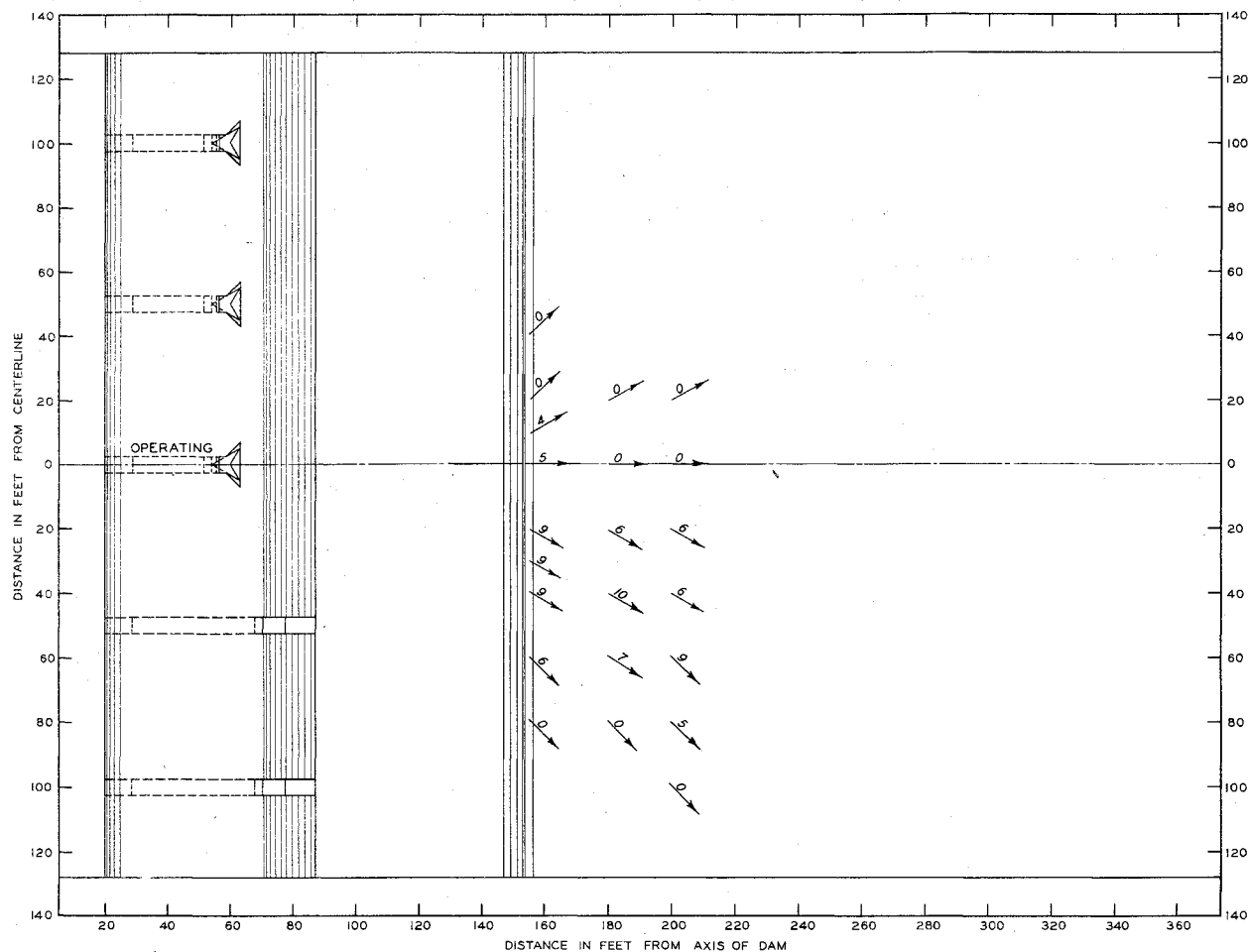
DISCHARGE	16,000 CFS
POOL ELEV	554.0
TAILWATER ELEV	511.5
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEVATION 484.0.



SECTION THROUGH CENTERLINE STILLING BASIN

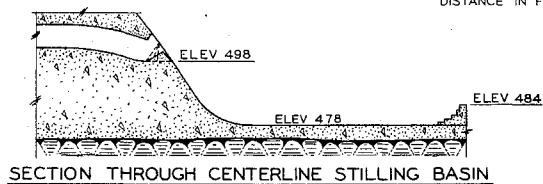
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



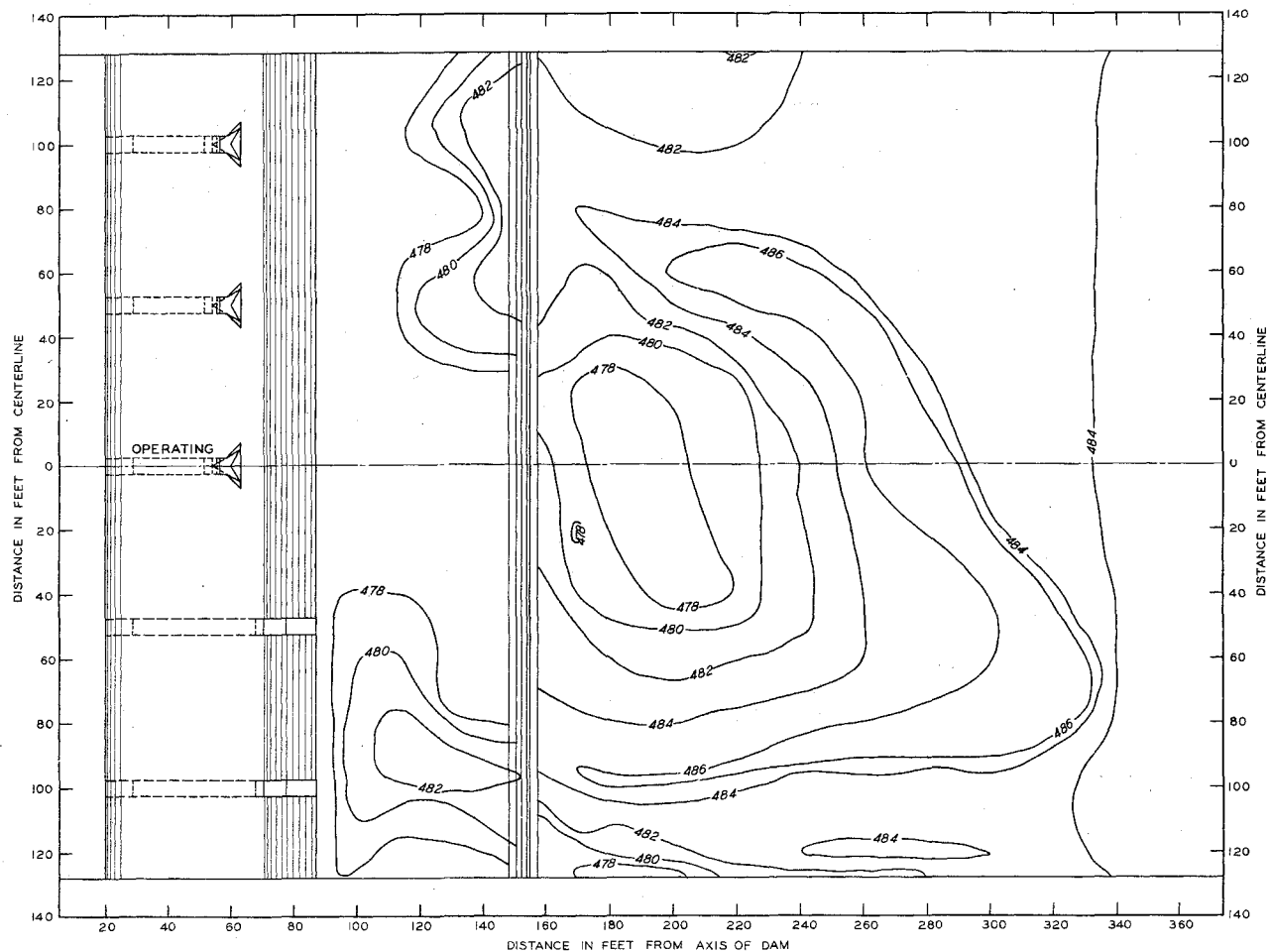
TEST CONDITIONS

DISCHARGE	1,720 CFS
POOL ELEV	5540
TAILWATER ELEV	491.3
LENGTH OF BASIN	70 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 484.0.



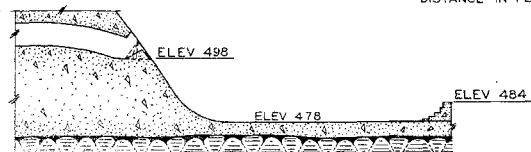
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



#### TEST CONDITIONS

DISCHARGE	1,720 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	70 FT

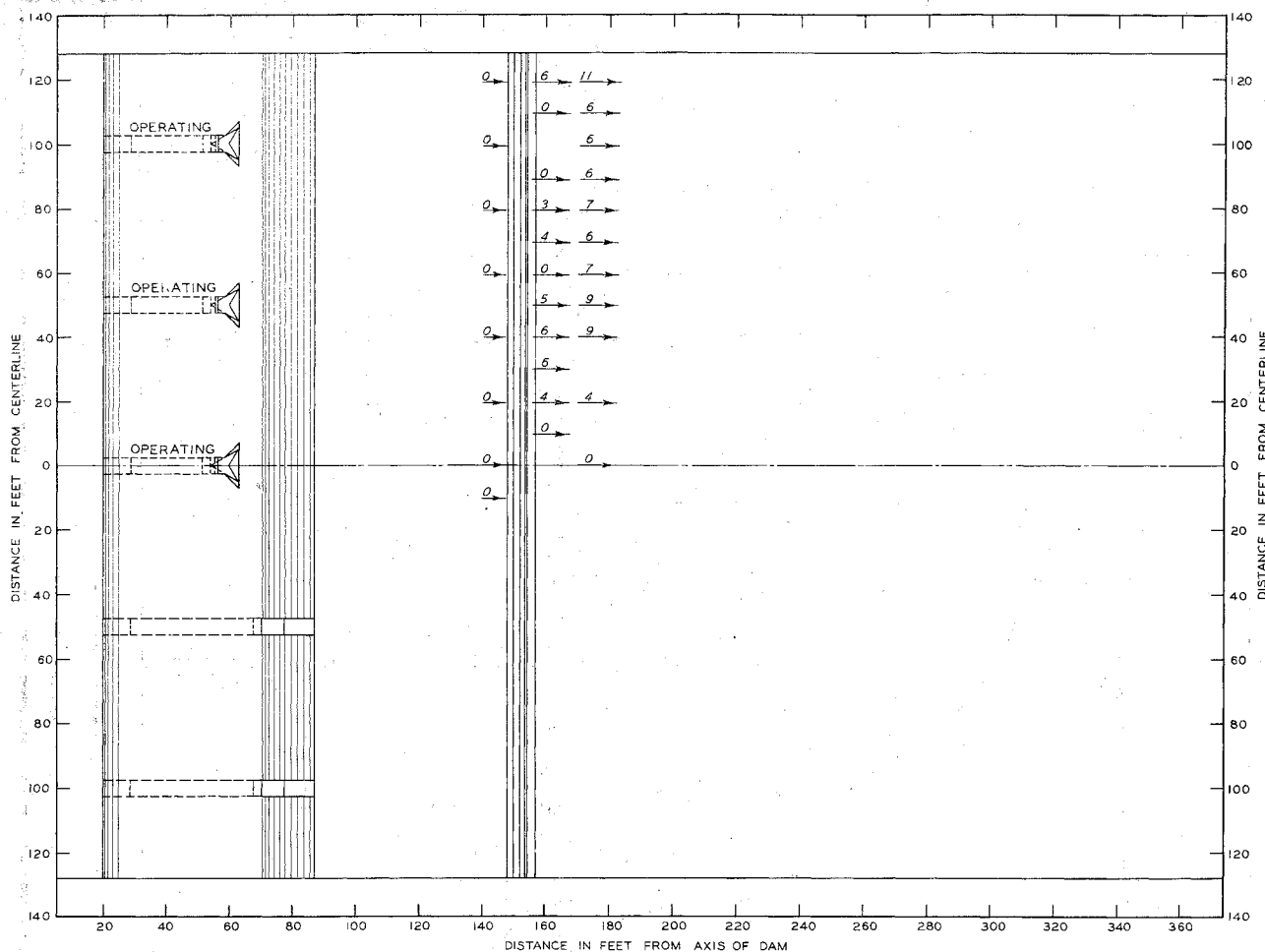
NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 484.0.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA

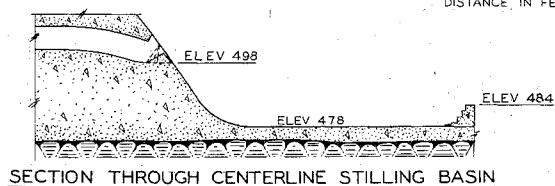
SCOUR PATTERN



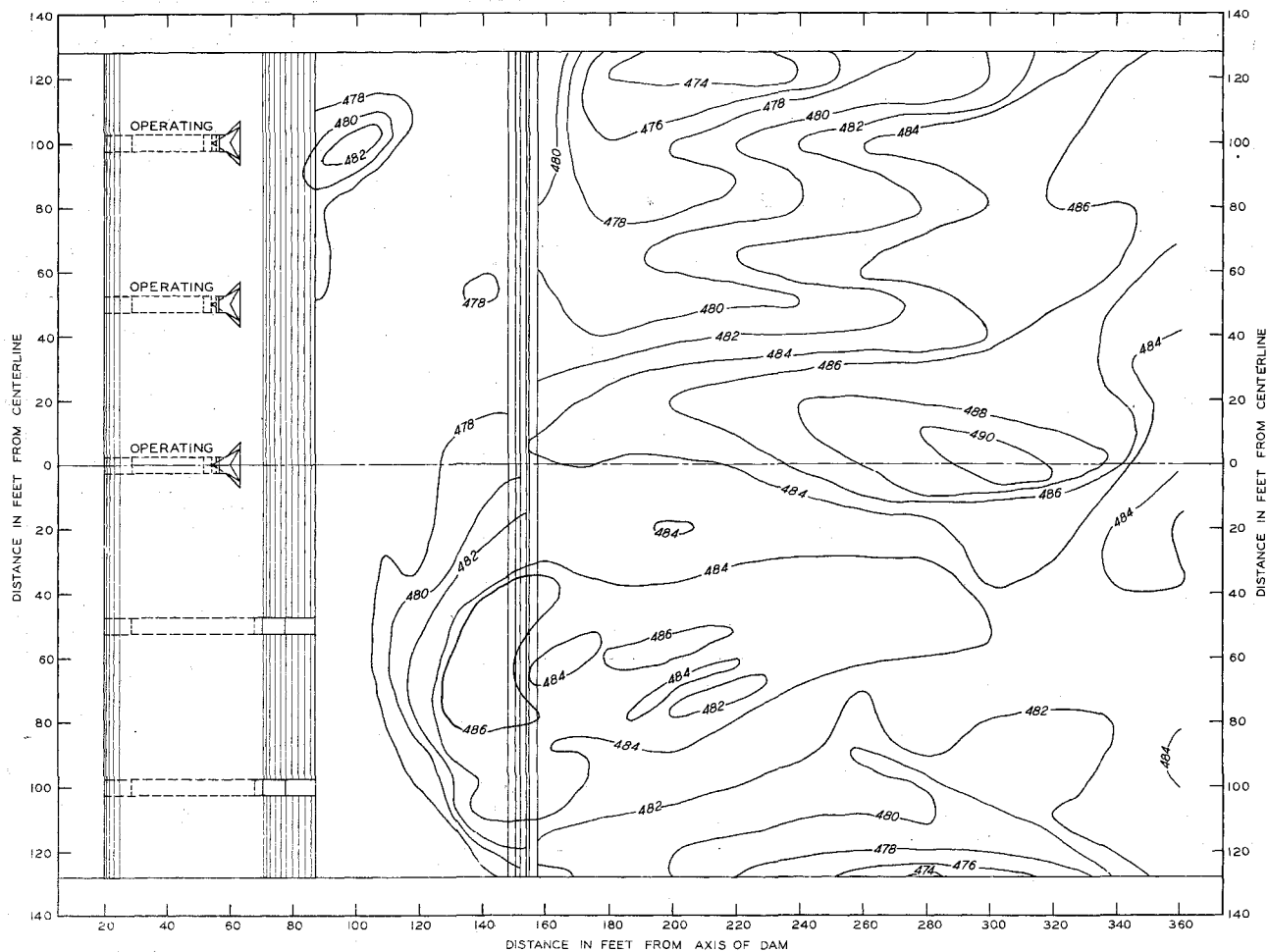
# TEST CONDITIONS

DISCHARGE	16,933 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	70 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 484.0.



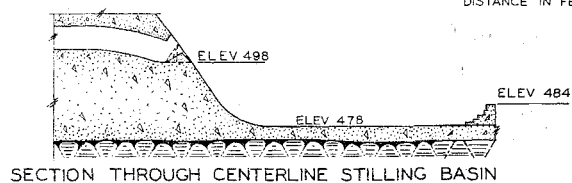
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



#### TEST CONDITIONS

DISCHARGE	16,933 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	70 FT

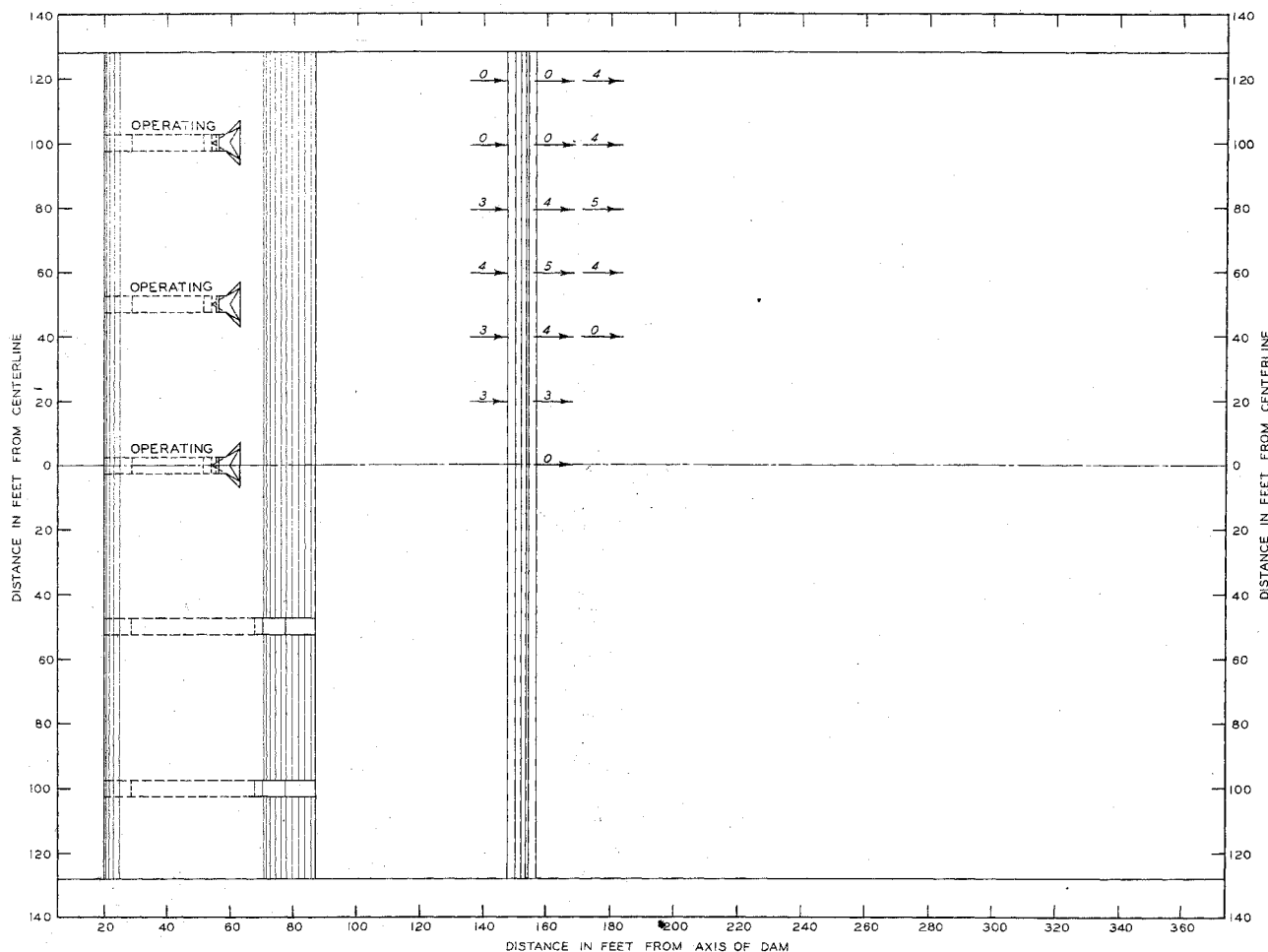
NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 484.0.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA

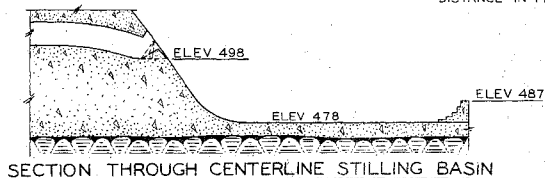
SCOUR PATTERN



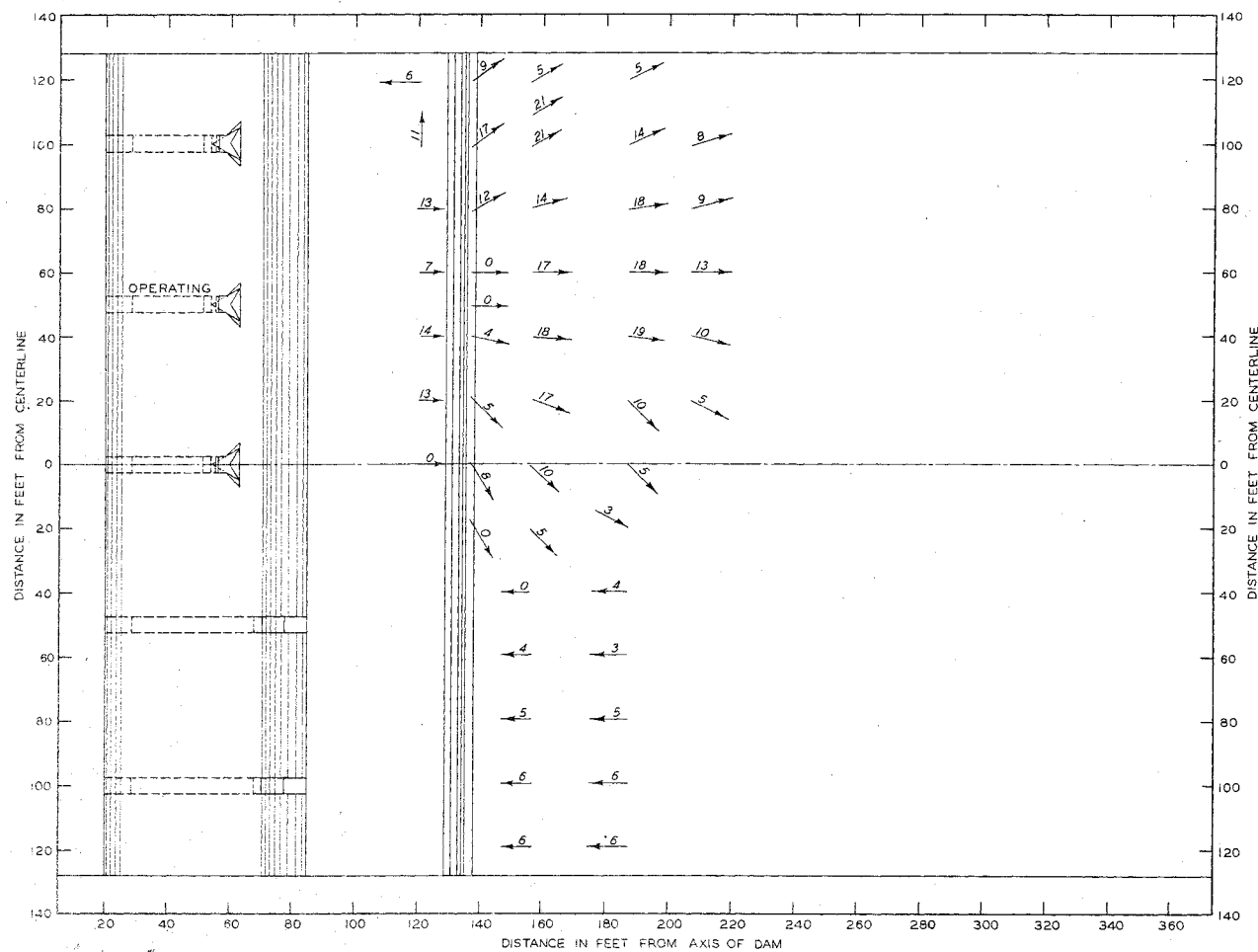
# TEST CONDITIONS

DISCHARGE	16,000 CFS
POOL ELEV	554.0
TAILWATER ELEV	511.5
LENGTH OF BASIN	70 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEVATION 487.0.



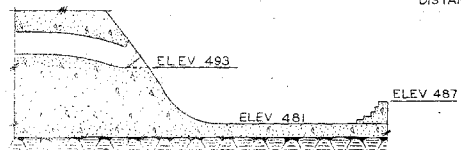
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



# TEST CONDITIONS

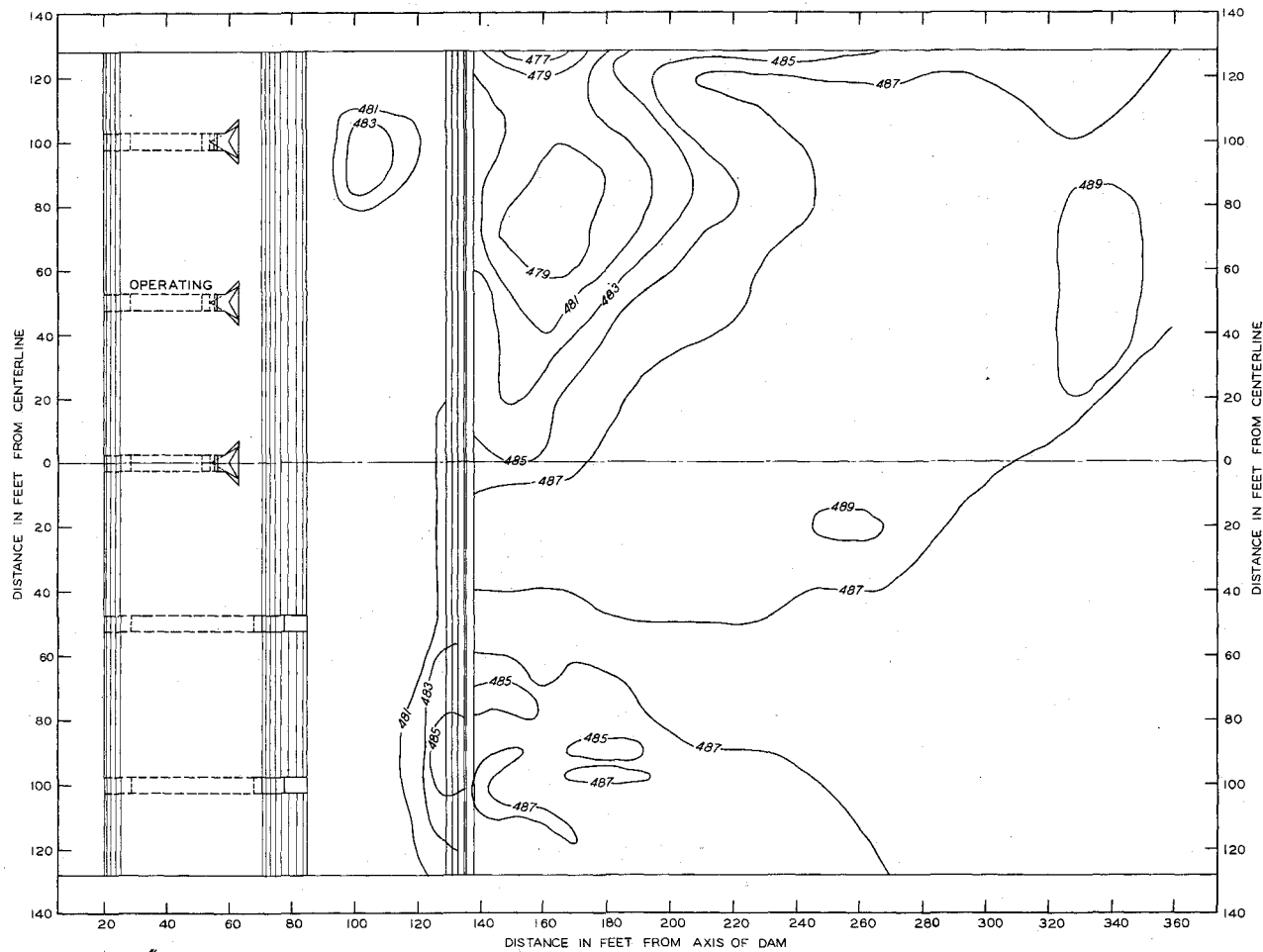
DISCHARGE	1,750 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 487.0.



SECTION THROUGH CENTERLINE STILLING BASIN

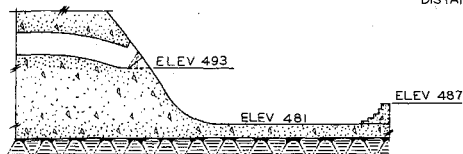
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



# TEST CONDITIONS

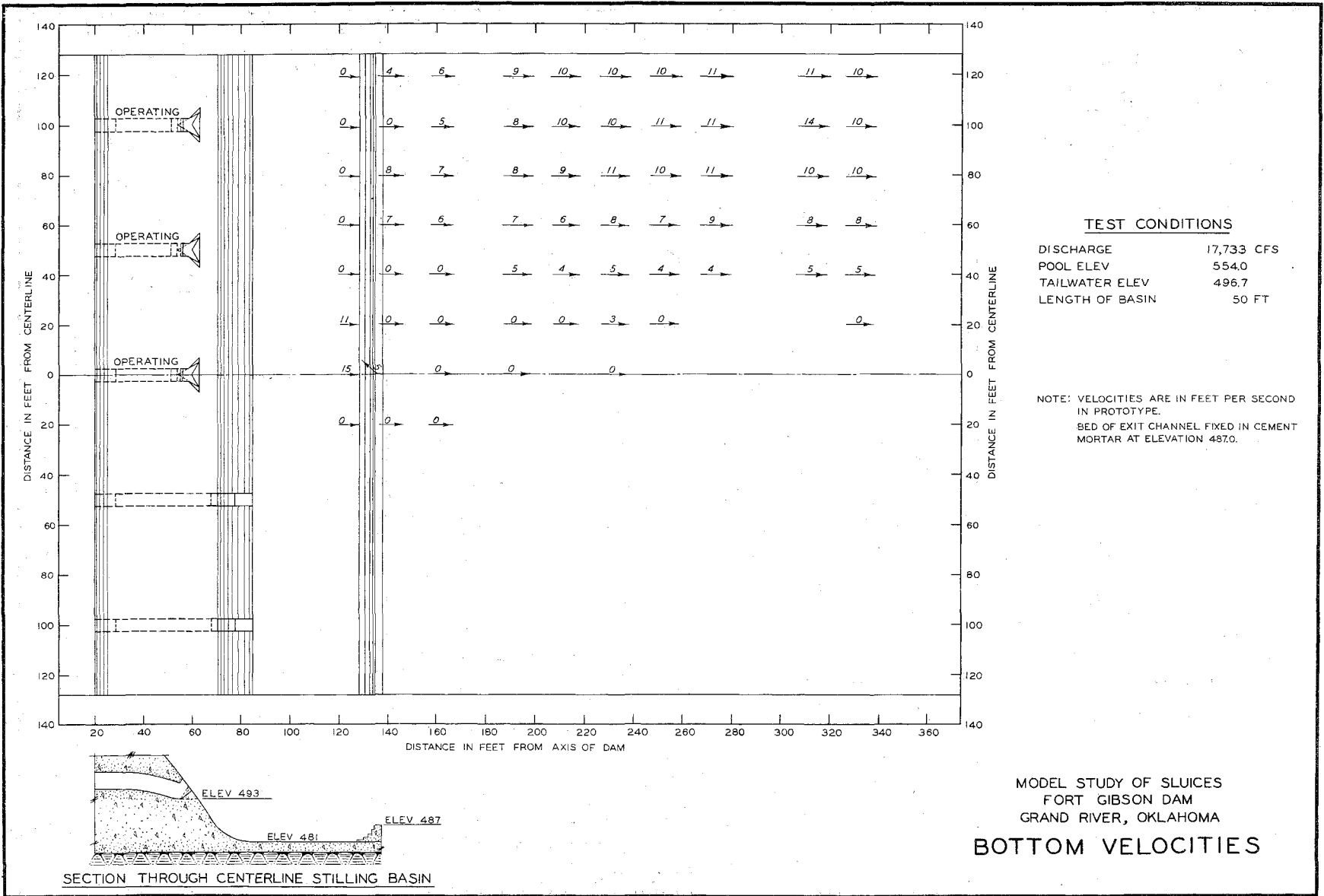
DISCHARGE	1,750 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

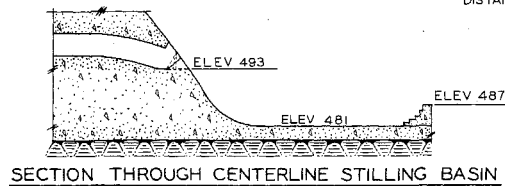
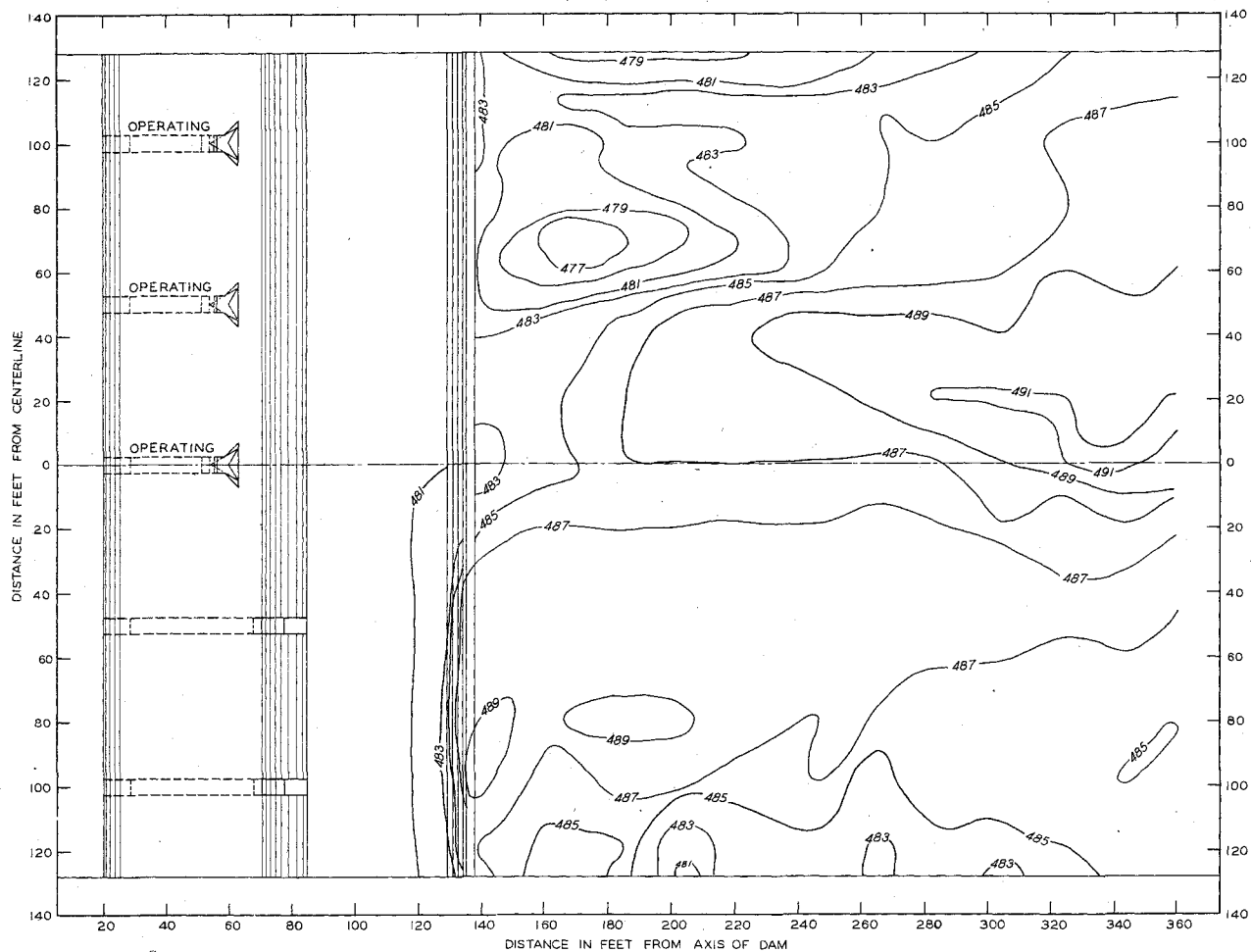
NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 487.0.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
SCOUR PATTERN





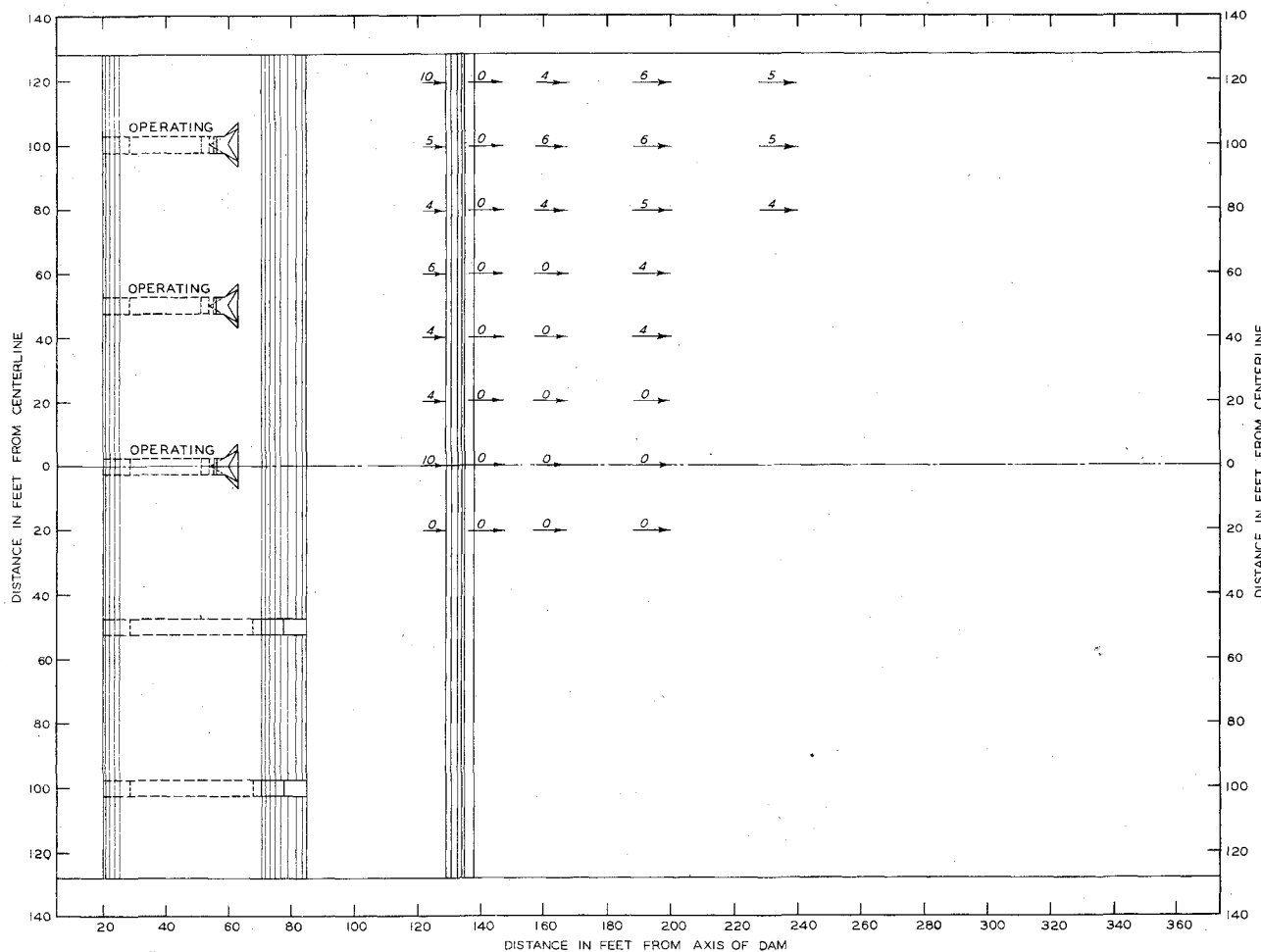
# TEST CONDITIONS

DISCHARGE	17,733 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	50 FT

NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 487.0.

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA

SCOUR PATTERN

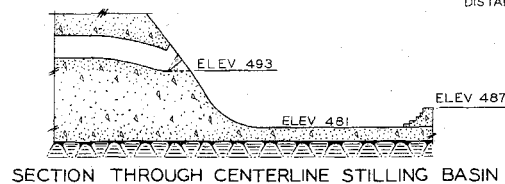


#### TEST CONDITIONS

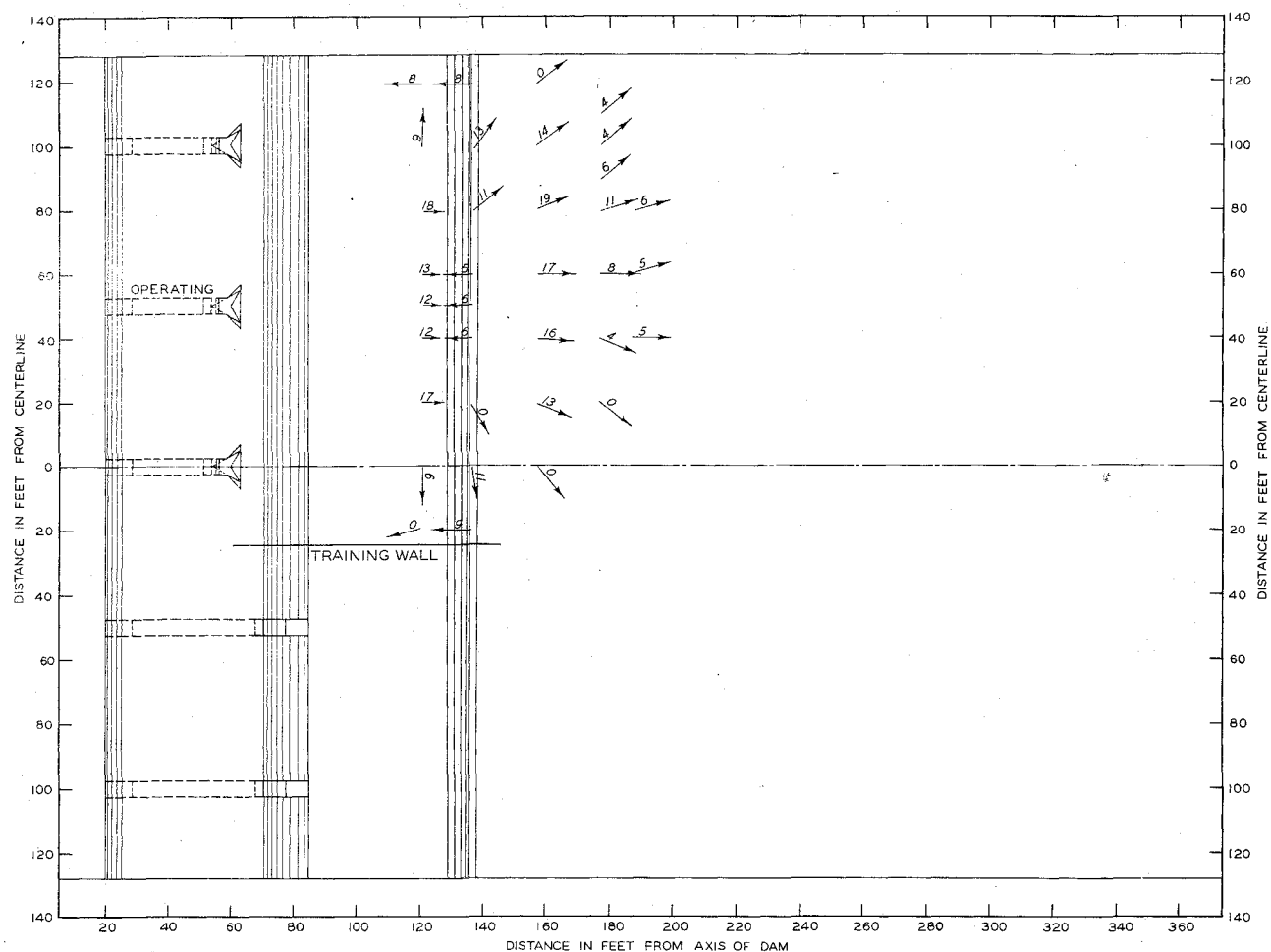
DISCHARGE	15,400 CFS
POOL ELEV	554.0
TAILWATER ELEV	511.5
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.

BED OF EXIT CHANNEL FIXED IN  
CEMENT MORTAR AT ELEVATION 487.0.



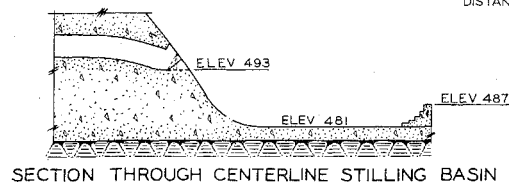
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



# TEST CONDITIONS

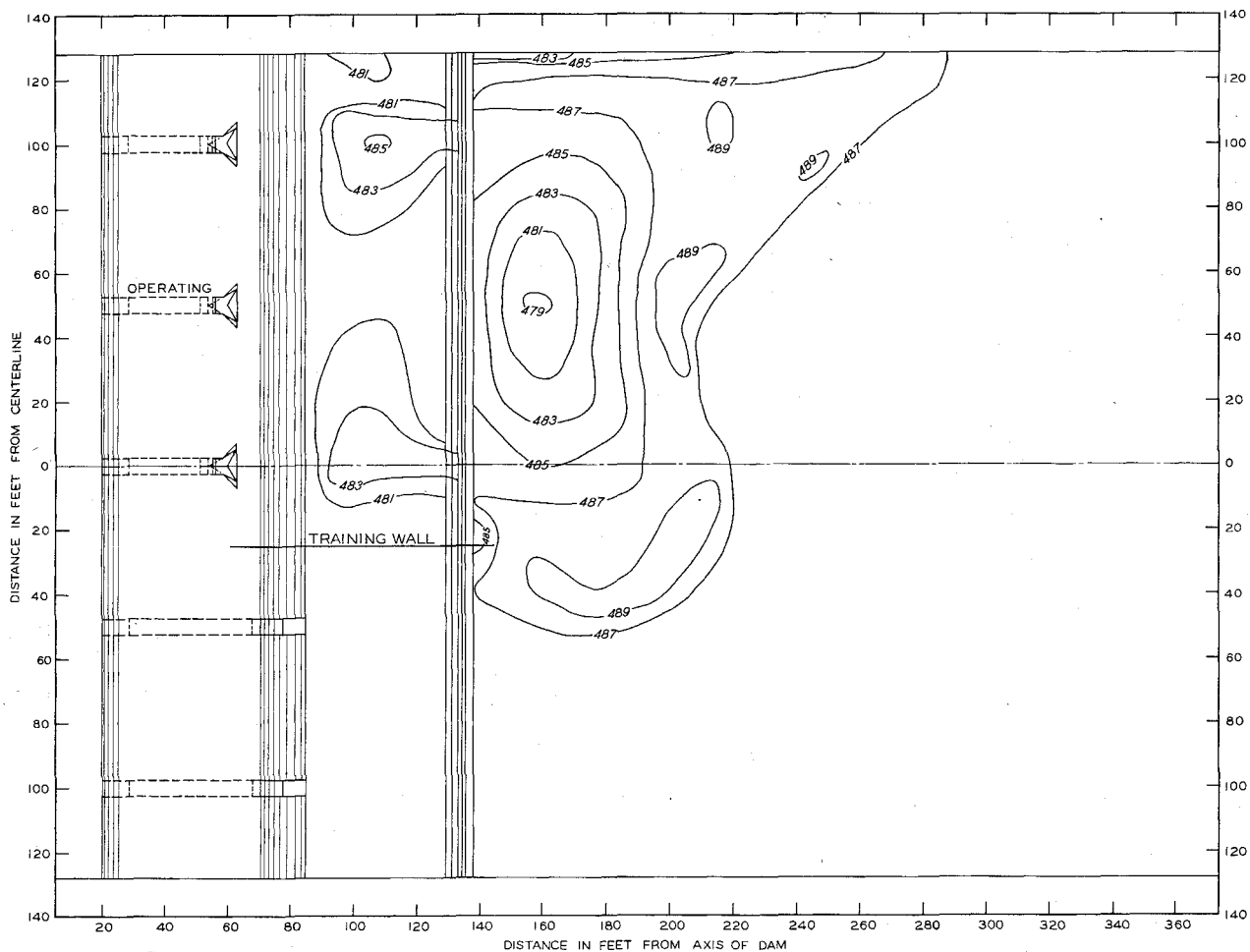
DISCHARGE	1,750 CFS
POOL ELEV	544.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 487.0.



SECTION THROUGH CENTERLINE STILLING BASIN

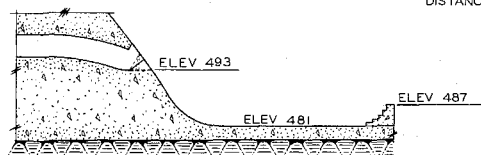
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



#### TEST CONDITIONS

DISCHARGE	1,750 CFS
POOL ELEV	554.0
TAILWATER ELEV	491.3
LENGTH OF BASIN	50 FT

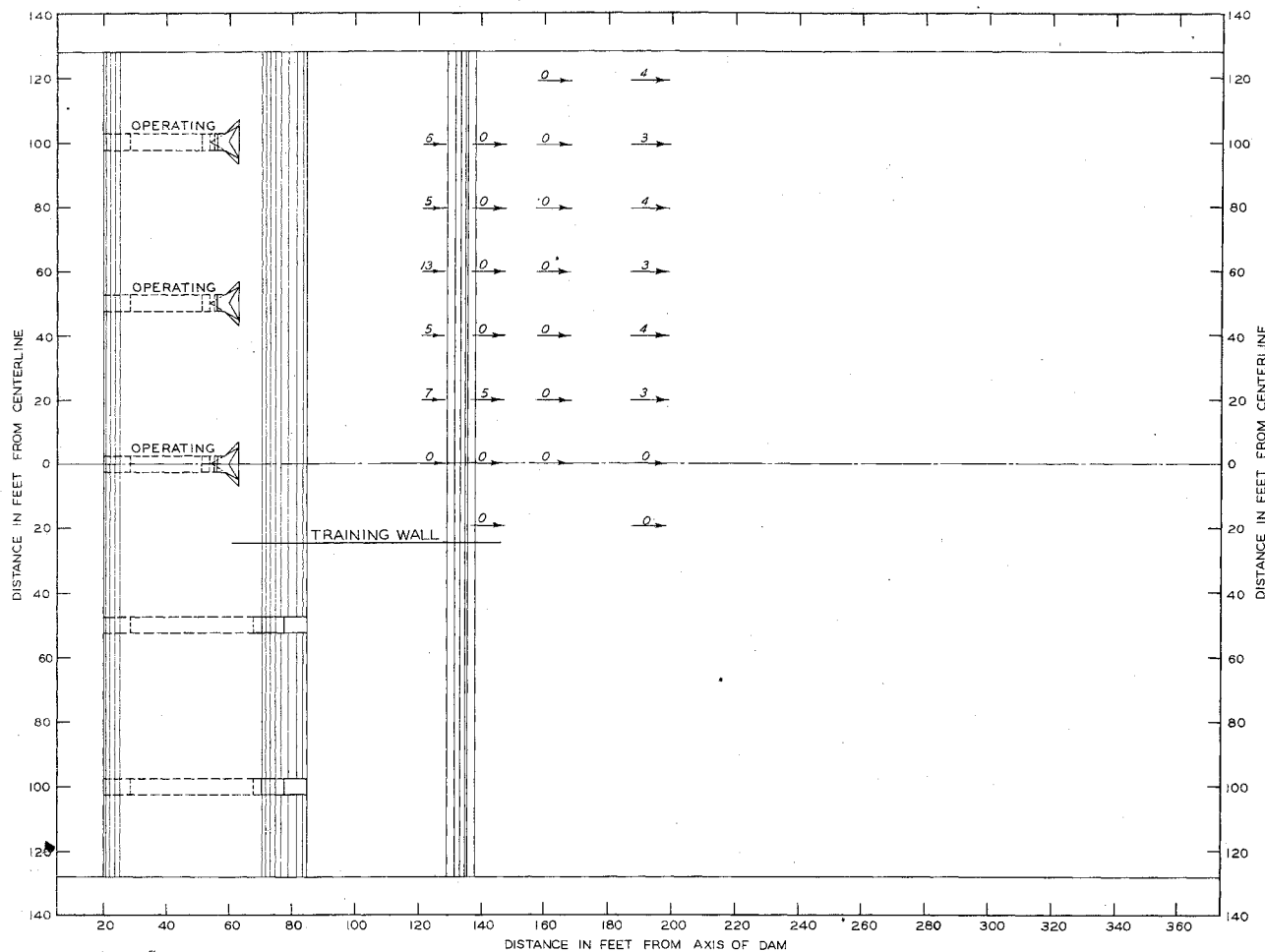
NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 487.0.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA

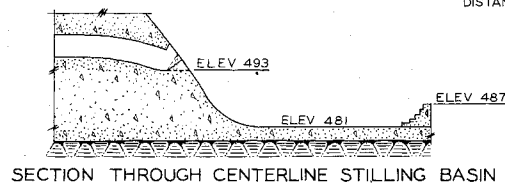
SCOUR PATTERN



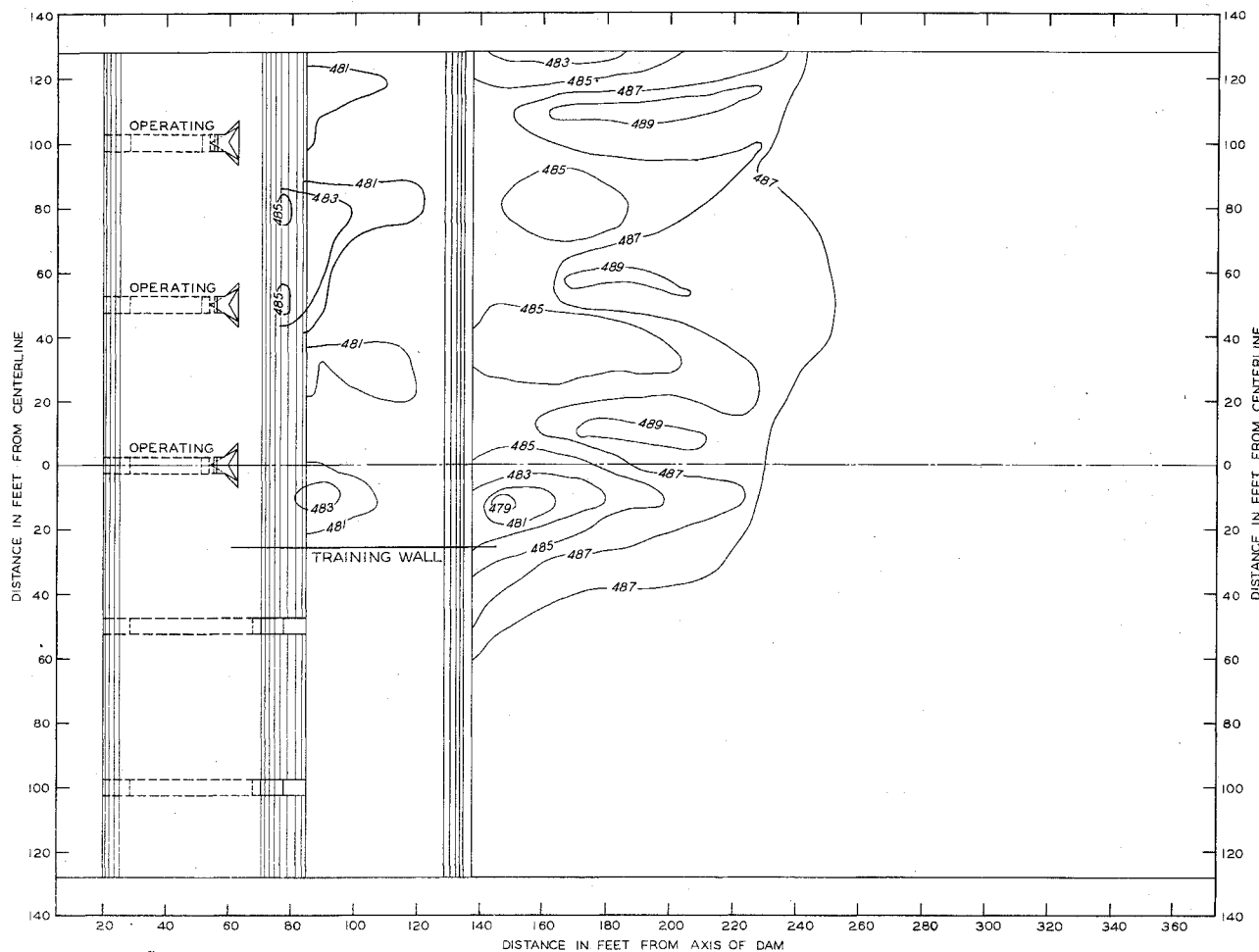
### TEST CONDITIONS

DISCHARGE	17,733 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 487.0.



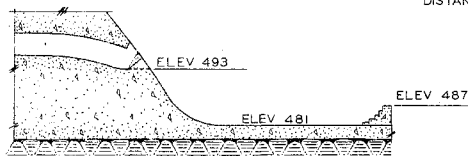
MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**



#### TEST CONDITIONS

DISCHARGE	17,733 CFS
POOL ELEV	554.0
TAILWATER ELEV	496.7
LENGTH OF BASIN	50 FT

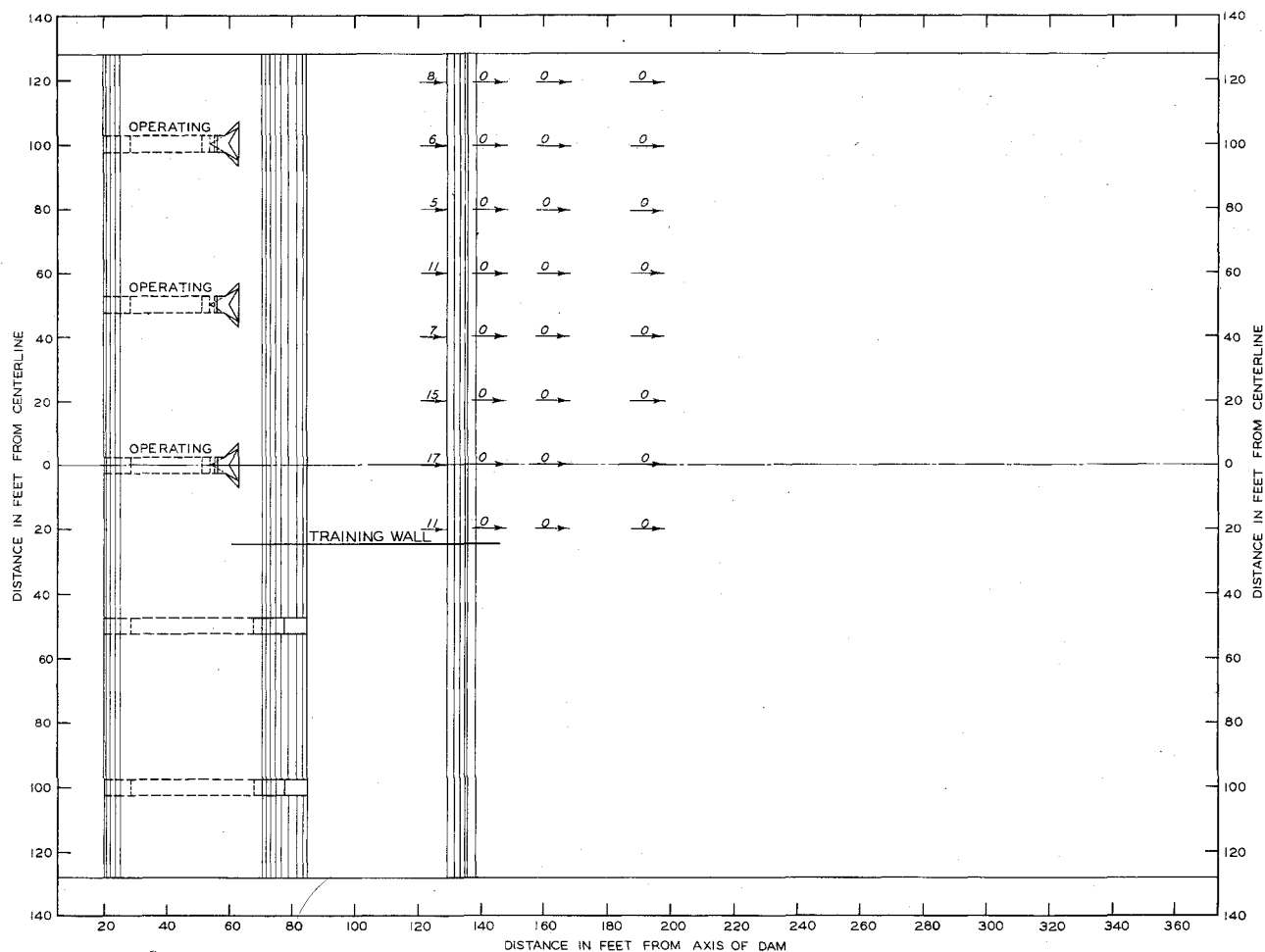
NOTE: BED OF EXIT CHANNEL MOLDED  
FLAT TO ELEVATION 487.0.



SECTION THROUGH CENTERLINE STILLING BASIN

MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA

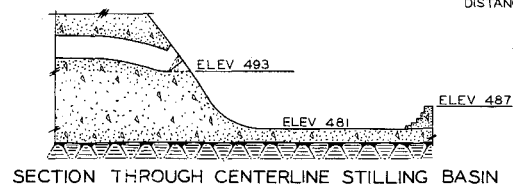
#### SCOUR PATTERN



# TEST CONDITIONS

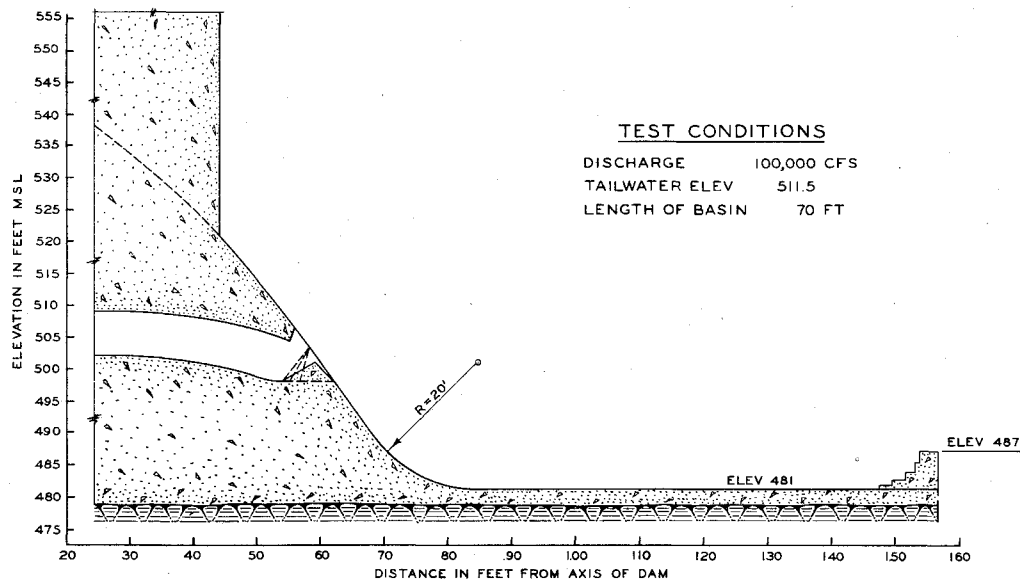
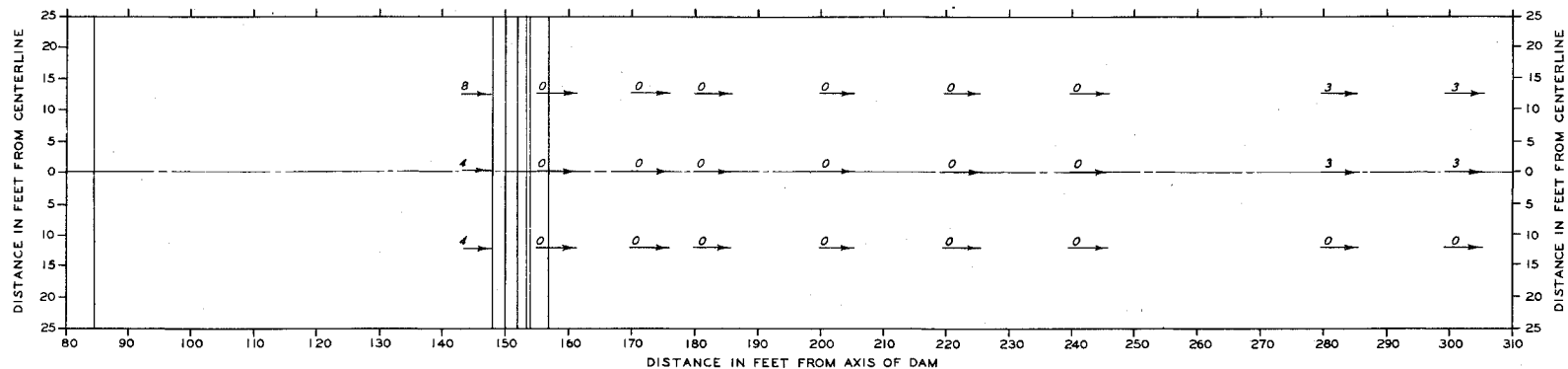
DISCHARGE	15,400 CFS
POOL ELEV	554.0
TAILWATER ELEV	511.5
LENGTH OF BASIN	50 FT

NOTE: VELOCITIES ARE IN FEET PER SECOND  
IN PROTOTYPE.  
BED OF EXIT CHANNEL FIXED IN CEMENT  
MORTAR AT ELEVATION 487.0.



MODEL STUDY OF SLUICES  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
**BOTTOM VELOCITIES**





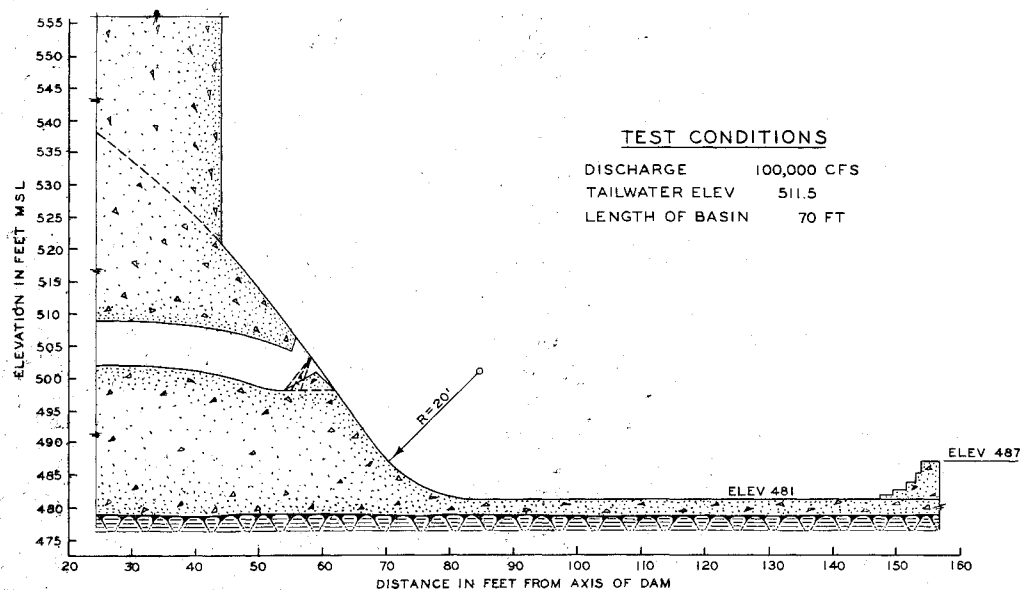
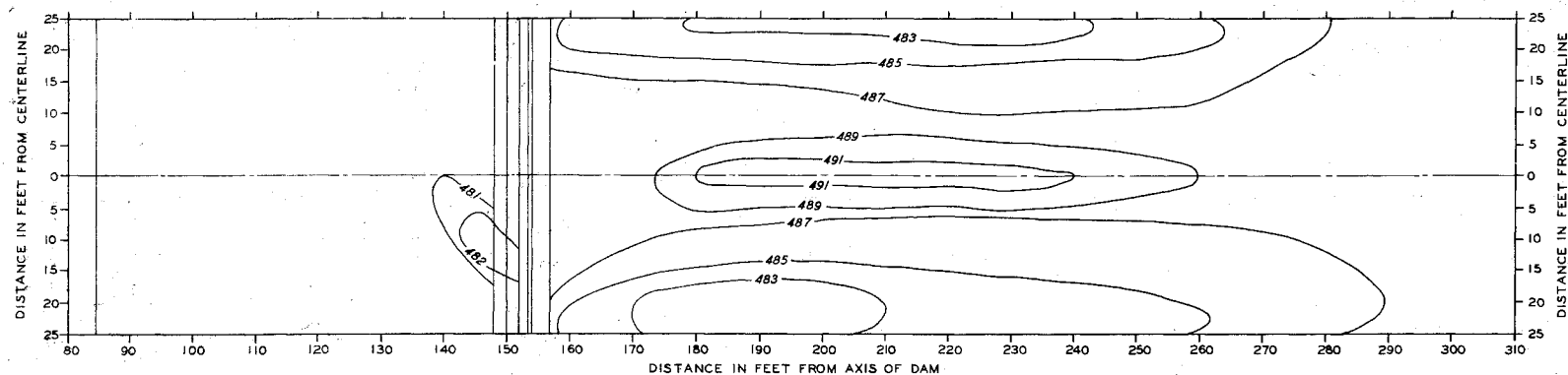
#### TEST CONDITIONS

DISCHARGE 100,000 CFS  
 TAILWATER ELEV 511.5  
 LENGTH OF BASIN 70 FT

NOTE: COMBINED ACTION OF SPILLWAY AND SLUICE  
 WAS INVOLVED.  
 VELOCITIES ARE IN FEET PER SECOND IN  
 PROTOTYPE.  
 BED OF EXIT CHANNEL WAS FIXED IN CEMENT  
 MORTAR AT ELEVATION 487.0.

MODEL STUDY OF  
 FORT GIBSON DAM  
 GRAND RIVER, OKLAHOMA  
 SECTION OF SPILLWAY, SLUICE, AND STILLING BASIN  
**BOTTOM VELOCITIES**



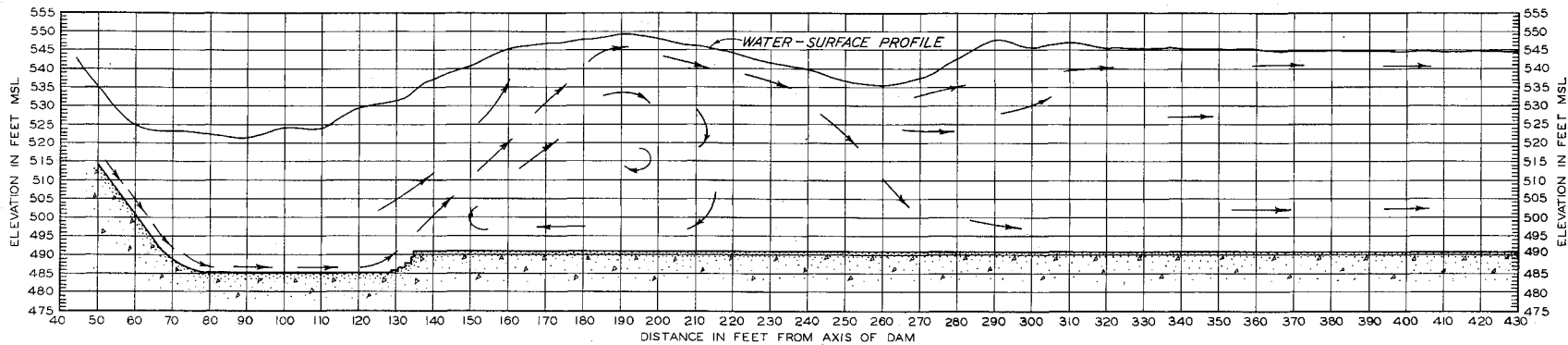


#### TEST CONDITIONS

DISCHARGE 100,000 CFS  
TAILWATER ELEV 511.5  
LENGTH OF BASIN 70 FT

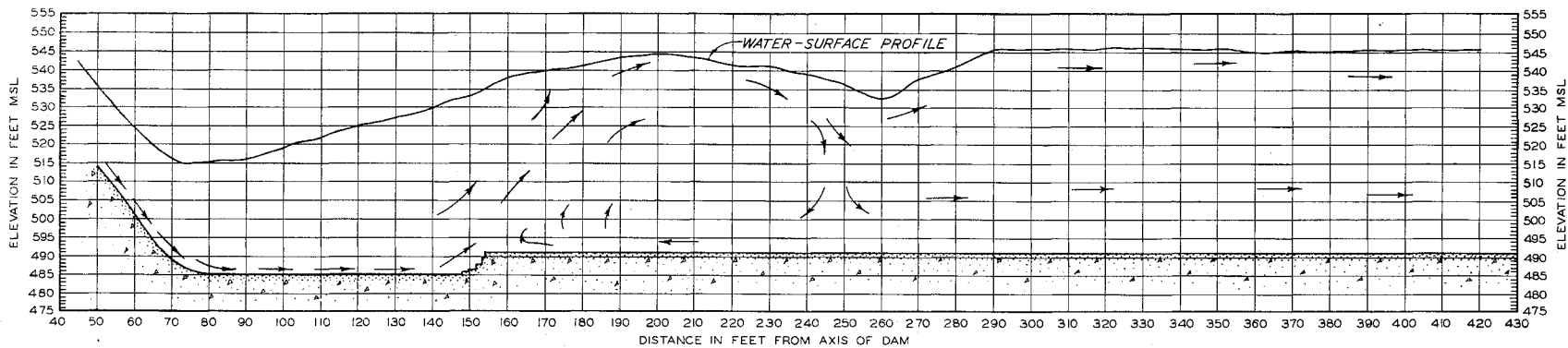
NOTE: BED OF EXIT CHANNEL MOLDED FLAT TO ELEVATION 487.  
COMBINED ACTION OF SPILLWAY AND SLUICE WAS INVOLVED.

MODEL STUDY OF  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
SECTION OF SPILLWAY, SLUICE, AND STILLING BASIN  
**SCOUR PATTERN**



TEST CONDITIONS

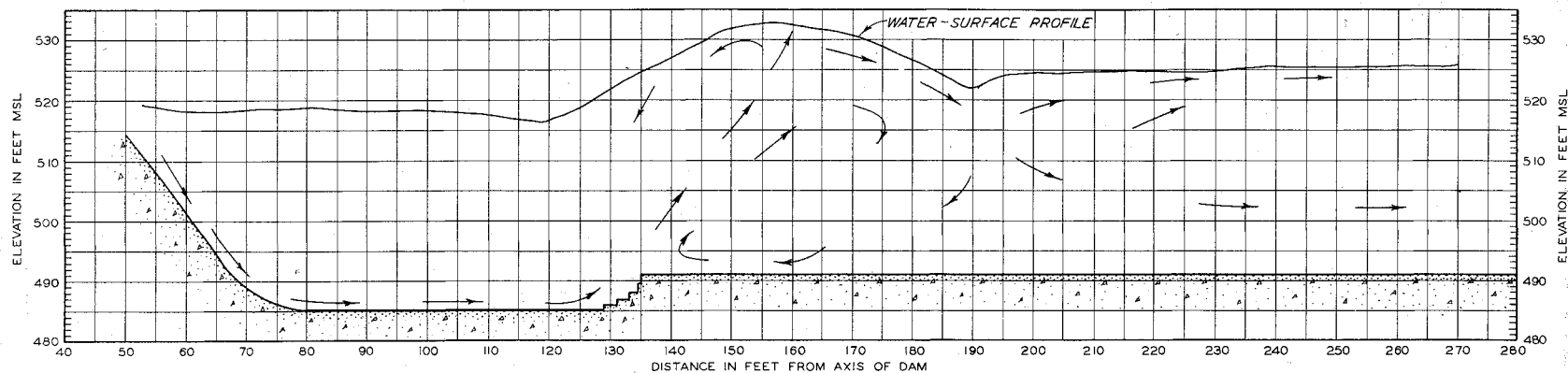
DISCHARGE 1,020,000 CFS  
 TAILWATER ELEV 545.5  
 LENGTH OF BASIN 50 FT



TEST CONDITIONS

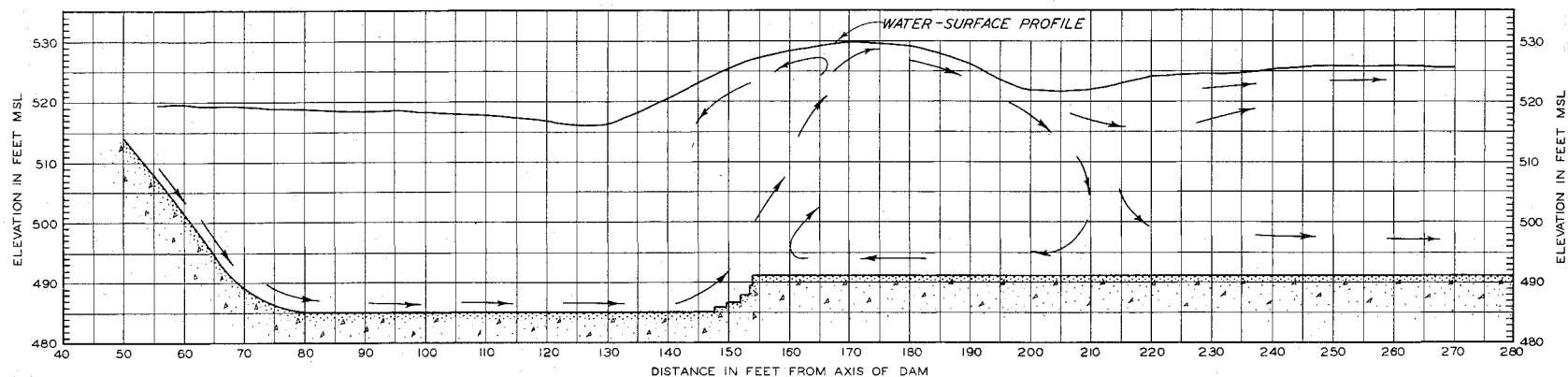
DISCHARGE 1,020,000 CFS  
 TAILWATER ELEV 545.5  
 LENGTH OF BASIN 70 FT

MODEL STUDY OF  
 FORT GIBSON DAM  
 GRAND RIVER, OKLAHOMA  
 SECTION OF SPILLWAY AND STILLING BASIN  
**FLOW CHARACTERISTICS**



TEST CONDITIONS

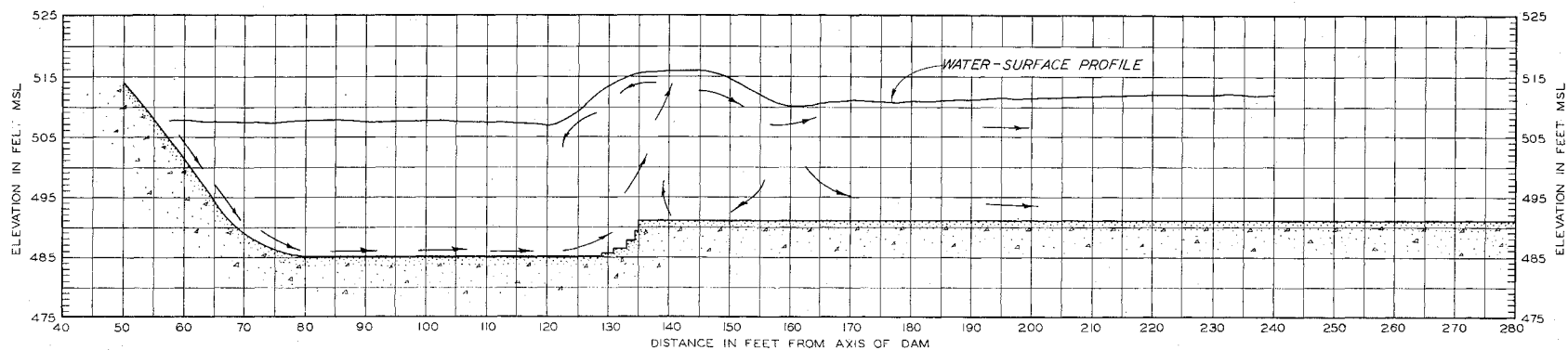
DISCHARGE 300,000 CFS  
TAILWATER ELEV 525.8  
LENGTH OF BASIN 50 FT



TEST CONDITIONS

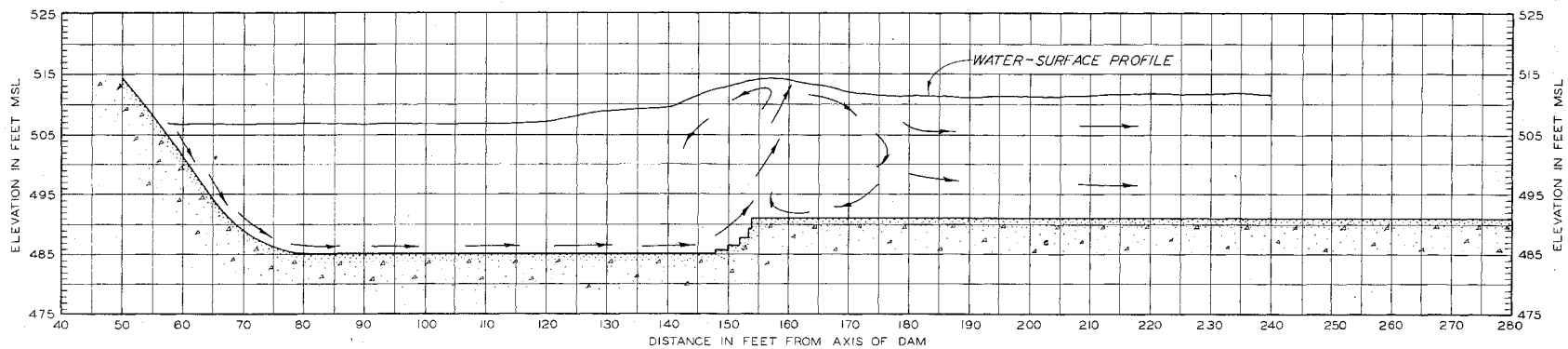
DISCHARGE 300,000 CFS  
TAILWATER ELEV 525.8  
LENGTH OF BASIN 70 FT

MODEL STUDY OF  
FORT GIBSON DAM  
GRAND RIVER, OKLAHOMA  
SECTION OF SPILLWAY AND STILLING BASIN  
**FLOW CHARACTERISTICS**



TEST CONDITIONS

DISCHARGE 100,000 CFS  
 TAILWATER ELEV 511.5  
 LENGTH OF BASIN 50 FT

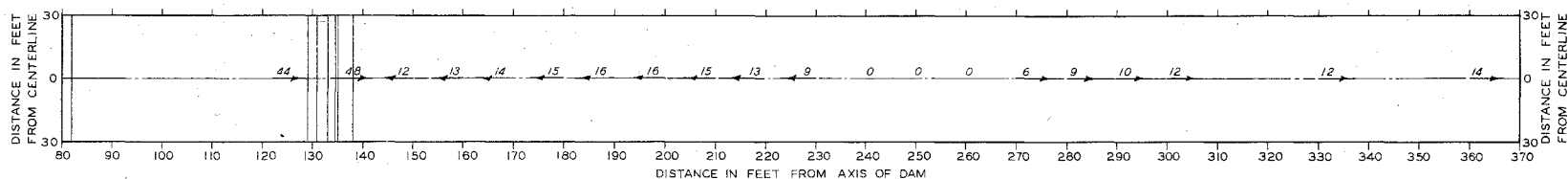


TEST CONDITIONS

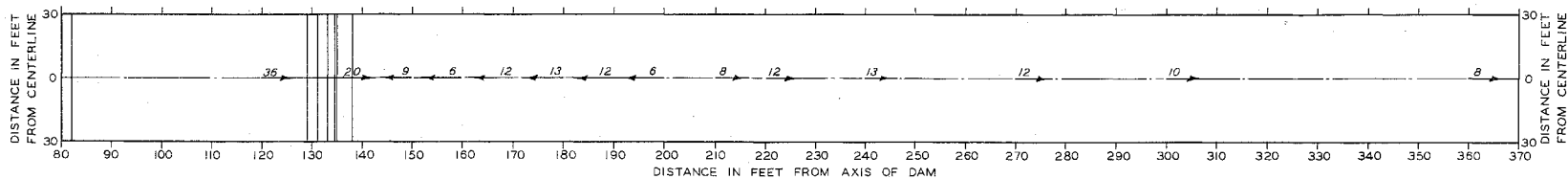
DISCHARGE 100,000 CFS  
 TAILWATER ELEV 511.5  
 LENGTH OF BASIN 70 FT

MODEL STUDY OF  
 FORT GIBSON DAM  
 GRAND RIVER, OKLAHOMA  
 SECTION OF SPILLWAY AND STILLING BASIN

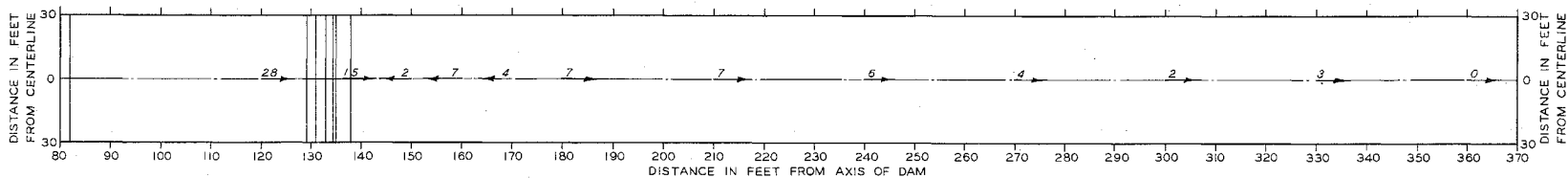
**FLOW CHARACTERISTICS**



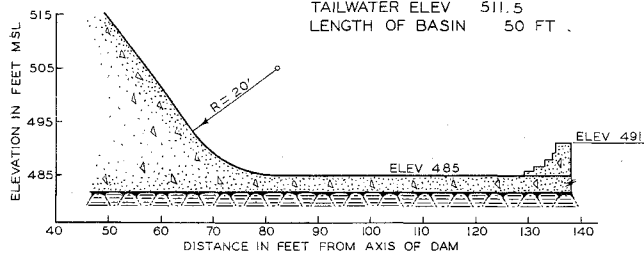
**TEST CONDITIONS**  
 DISCHARGE 1,020,000 CFS  
 TAILWATER ELEV 545.5  
 LENGTH OF BASIN 50 FT



**TEST CONDITIONS**  
 DISCHARGE 300,000 CFS  
 TAILWATER ELEV 525.8  
 LENGTH OF BASIN 50 FT

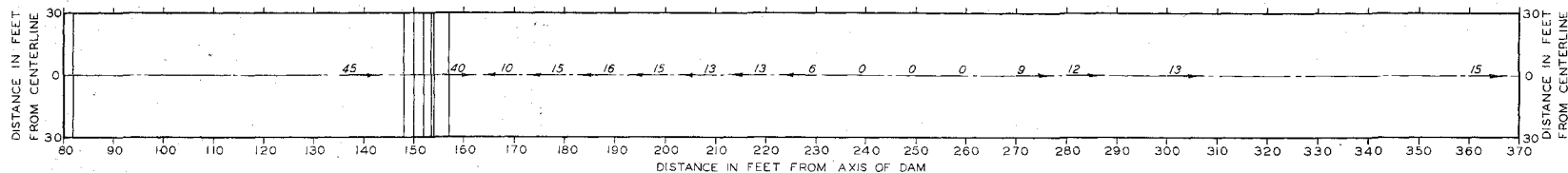


**TEST CONDITIONS**  
 DISCHARGE 100,000 CFS  
 TAILWATER ELEV 511.5  
 LENGTH OF BASIN 50 FT

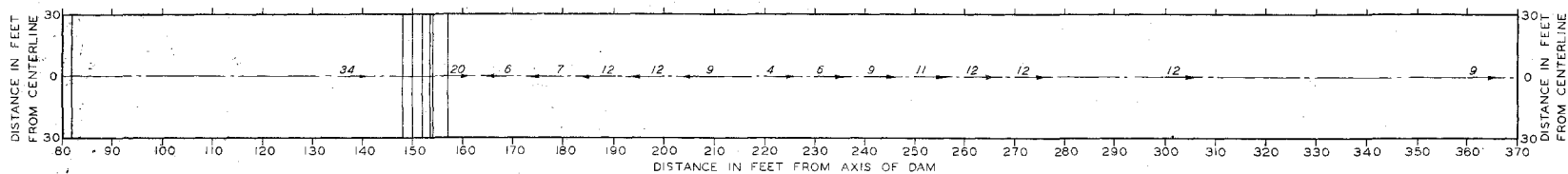


NOTE: VELOCITIES ARE IN FEET PER SECOND  
 IN PROTOTYPE.  
 BED OF EXIT CHANNEL FIXED IN  
 CEMENT MORTAR AT ELEVATION 491.

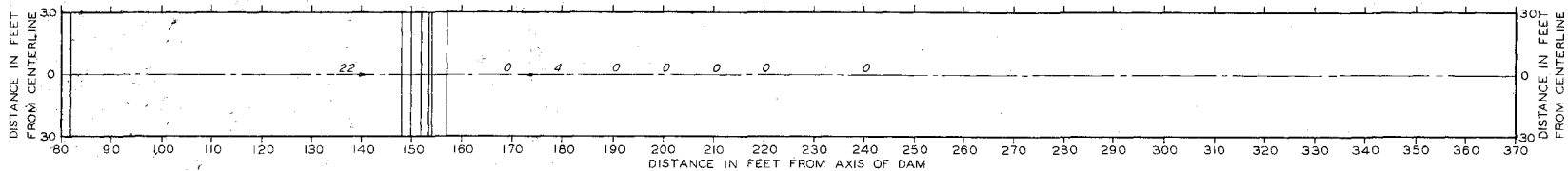
MODEL STUDY OF  
 FORT GIBSON DAM  
 GRAND RIVER, OKLAHOMA  
 SECTION OF SPILLWAY AND STILLING BASIN  
**BOTTOM VELOCITIES**



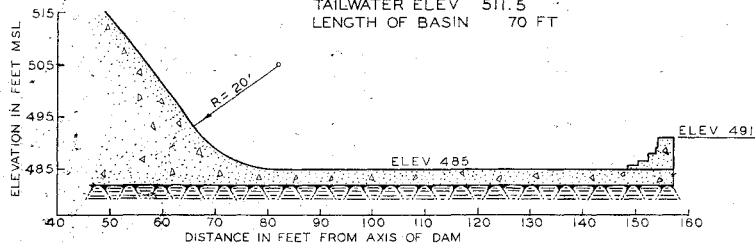
**TEST CONDITIONS**  
 DISCHARGE 1,020,000 CFS  
 TAILWATER ELEV 545.5  
 LENGTH OF BASIN 70 FT



**TEST CONDITIONS**  
 DISCHARGE 300,000 CFS  
 TAILWATER ELEV 525.8  
 LENGTH OF BASIN 70 FT



**TEST CONDITIONS**  
 DISCHARGE 100,000 CFS  
 TAILWATER ELEV 511.5  
 LENGTH OF BASIN 70 FT



NOTE: VELOCITIES ARE IN FEET PER SECOND IN PROTOTYPE.  
 BED OF EXIT CHANNEL FIXED IN CEMENT MORTAR AT ELEVATION 491.

MODEL STUDY OF  
 FORT GIBSON DAM  
 GRAND RIVER, OKLAHOMA  
 SECTION OF SPILLWAY AND STILLING BASIN

**BOTTOM VELOCITIES**